THE American JOURNAL OF Surgery

SIXTY-SEVENTH YEAR OF PUBLICATION

A PUBLICATION OF THE *Yorke* GROUP

MAY 1958

MAY 1958

THE American JOURNAL OF Surgery

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The American Journal of Surgery is published monthly by The American Journal of Surgery, Inc., 11 East 36th Street, New York 16, N. Y. Yearly Subscription, $15.00 U. S. A.; $16.00 Canada; $17.00 Foreign including Pan-American Countries. Single Numbers $2.00; Special and Symposium Numbers $4.00. Second-class mail privileges authorized at New York, N. Y. with additional second-class mail privileges authorized at York, Pa.— New Series, Volume 95, No. 5.
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MANUSCRIPTS: All manuscripts should be typewritten double space and addressed to the Editorial Office of the Journal, 11 East 36th Street, New York 16, N. Y. The top should be indicated on the back of each photograph. *Style for bibliography:* DOE, J. J. Modern technics in surgery. Am. J. Surg., 5:93, 1950.

Change of address must reach us one month preceding month of issue.

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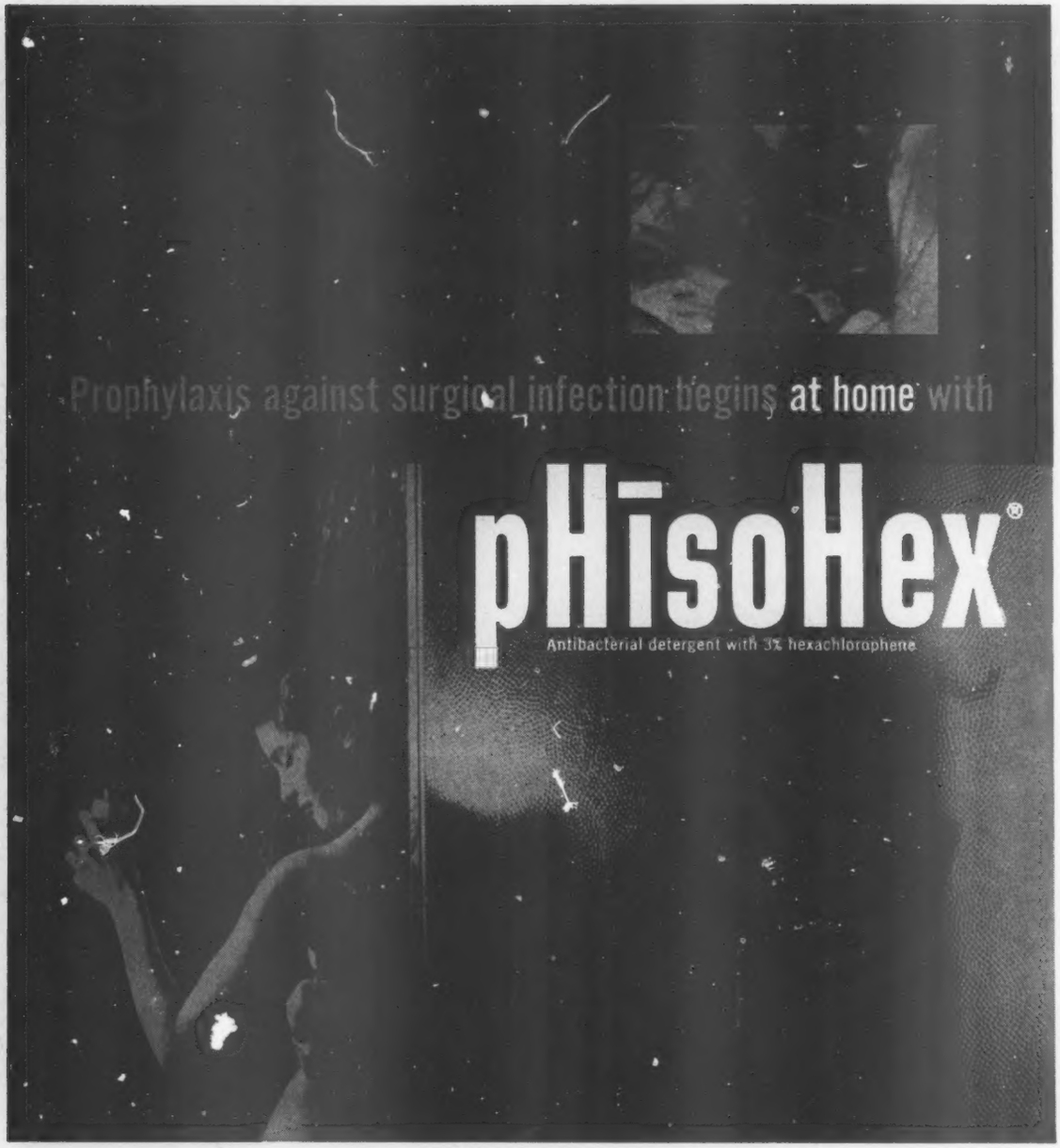
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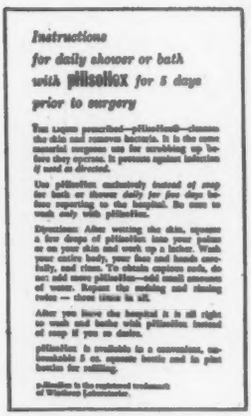

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The American Journal of Surgery

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PALUEL J. FLAGG

SCIENTIFIC PAPERS

The Osgood-Schlatter Lesion. A Radiological and Histological Study 731

B. COHEN AND R. W. WILKINSON

Eleven cases of Osgood-Schlatter disease are presented, in seven of which histological examination of the tubercle was positive. There is no justification for regarding this condition as an aseptic necrosis of bone, nor should it be grouped with the osteochondroses. The authors suggest the term Osgood-Schlatter disease is a misnomer, that a more accurate term, and less misleading, is the Osgood-Schlatter lesion.

Coronary Heart Disease. Three Dominant Causes of Death 743

CLAUDE S. BECK

From an experience of 500 operations on patients with coronary heart disease the author has analyzed the dominant factors producing death. An unstable electrical condition in the heart, reduction of total coronary artery inflow, and destruction of muscle compose one or more of the dominant factors producing deaths in these patients.

Replacement of Shaft Defects of Long Bones by Metallic Prostheses 752

COL. ERNEST A. BRAV, MAJOR JAMES G. MCFADDIN AND MAJOR JAMES A. MILLER

A clinical and experimental study of the bridging of defects in the shafts of long bones by Vitallium prostheses. Only one patient in five retained his prosthesis. In animals in which there was no local trauma the prostheses were adequately covered by soft tissue, were well tolerated and all were retained. Further investigation of the bridging of bone defects by foreign materials seems justified.

Effect of Compression on the Rate of Fracture Healing Using a Special Plate . 761

GEORGE W. BAGBY AND JOSEPH M. JANES

An interesting study of the effect of a compressing force at the site of a fracture. This interest stems from Wolff's law which deals with the effect of stresses and strains on the architecture of bone.

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3. *Kern, E. C.: Preoperative sedation with meprobamate (Miltown) in surgery of eye, ear, nose and throat. Eye, Ear, Nose & Throat Month.* **36**: *408, July 1957.*

CH-6088

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A Survey of Gastric Surgery for Ulcer and Neoplasm 772

HOWARD A. WEINBERGER, JOHN O. VIETA AND JOHN C. PATTEN

An analysis was made of 683 patients who underwent gastric surgery in a voluntary hospital in a ten-year period. The cases are divided into four groups: (1) gastric neoplasms, (2) gastroduodenal ulcerations with perforations, (3) gastroduodenal ulcerations with exsanguinating hemorrhage, (4) gastroduodenal ulcerations treated electively.

Duodenostomy in Gastric Resection for Duodenal Ulcer 781

KARL MORGAN LIPPERT AND CAPT. HUGH V. COLEMAN

Closure of the duodenal stump during gastric resection for peptic ulcer, especially in the presence of active inflammation about an ulcer penetrating into the head of the pancreas, always presents a problem. Mortality and morbidity statistics concerning peptic ulcer surgery, except for non-related causes, are largely built around duodenal stump complications. A simple duodenostomy procedure, using a French catheter, is described. Data on the authors' experience in treatment of 167 consecutive resections for duodenal ulcer in which tube duodenostomy was done twenty-one times, with a mortality of 2.9 per cent from all causes, are given.

Meperidine-Levallorphan in Anesthesia. Study of Usefulness of Such Mixtures in Supplementation of Nitrous Oxide-Oxygen-Thiopental Anesthesia 787

BERNARD R. MARGOLIUS AND EDITH R. KEPES

Four hundred surgical patients were studied, of whom 100 each received meperidine hydrochloride alone and meperidine-levallorphan tartrate mixtures in ratios of 100:1, 100:1.5 and 100:2 by continuous drip for supplementation of nitrous oxide-oxygen-thiopental sodium anesthesia. The four series were comparable as to age and sex distribution of patients, types of operations performed, premedications administered, anesthetic management and average duration of surgery. The findings presented suggest that the 100:1 ratio of meperidine to levallorphan is the combination of choice.

Vaginal Plastic Surgery Based on a New Concept of the Anatomy of the Female Genital Tract. v. Birth Injuries to the Perineum and Their Treatment, Preventive and Active 793

HERMAN SHANN

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Acute Volvulus of the Cecum 798

JAMES H. SAINT

The author discusses the general subject of acute volvulus of the cecum, including the pathogeneses and treatment. A recent case is presented of acute volvulus of the cecum, which lends itself well as a basis for the discussion of various clinical aspects of this condition.

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GARVER L. JENSEN

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Fistulotomy and Fistulectomy for Fistulas about the Anus and Rectum . . . 818

HYMAN SWERDLOW

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Basal Cell Carcinoma of the Anus 822

W. H. BUNSTOCK

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ROBERT EHRLICH

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Clinical Evaluation of Enzymatic Débridement with Papain-Urea-Chlorophyllin Ointment 828

JOHN F. BURKE AND THEODORE GOLDEN

The pertinent antecedent literature and background regarding the subject of enzymatic débridement of wounds and ulcers is reviewed. A preparation of papain-urea-chlorophyllin ointment has been utilized in twenty-seven cases over a period of eight months. The results achieved in all but one instance support the effectiveness of this preparation. The method of employment is simple and economical.

Secondary Amyloidosis in Injuries to the Spinal Cord 843

A. ESTIN COMARR

A very serious complication of decubitus ulcers among patients with injuries to the spinal cord is secondary amyloidosis. Over 2 per cent of patients afflicted with this trauma have had amyloidosis. The awareness of the complication is stressed.

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A Study of Operations upon the Gallbladder and Common Bile Duct 845

JAMES F. MARSHALL

A study has been made of 556 patients operated upon for inflammation or stones in the extrahepatic biliary system. The mortality rate for the various operative procedures is given. The author concludes that in the presence of an acute condition of the gallbladder in an elderly person, the indications for exploration of the common duct should be clear and that in the absence of jaundice one should consider postponing this procedure until a later date.

A Five-Year Survey of Acute Appendicitis 849

ENRIQUE T. YAP

The author reviews a five-year survey of acute appendicitis at the Maumee Valley Hospital, Toledo, Ohio (173 cases). Although this is considered a passé topic today, we believe this résumé merits publication (appendicitis still kills).

NEW INSTRUMENTS

Metal-Tipped Plastic Intravenous Needle 853

SIDNEY HIRSCH

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BEN E. FILLIS, ALAN W. GRANTHAM AND BERNARD J. CULLEN

Two unusual cases of multicystic kidney disease are presented, one in an infant and one in a fifty-three year old woman. The condition is believed to be congenital, unilateral and unlike polycystic kidney.

Renal Adenoma 862

D. B. STEARNS AND S. K. GORDON

A short review of the various factors, etiology, symptomatology, differential diagnosis and surgical treatment of renal adenoma. The authors present a typical case of this malady in a thirty-nine year old man with symptoms due to renal calculus who was found to have a mass of the same kidney by intravenous urogram. Operation and follow-up.

Choledochocolic Fistula. 866

WILLIAM C. T. GAYNOR AND WILLIAM C. L. DIEFENBACH

A case of choledochocolic fistula with operative repair is presented. A review of the literature leads the authors to believe theirs is the only patient to survive such a fistula.

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Gastric Re-resection 869

THOMAS C. CASE

A procedure employed for re-resection of the gastric remnant is suggested. Two case reports are presented.

Intestinal Polyposis with Oral Pigmentation. 873

DONALD F. GUISTO, HARRY E. RAITANO AND LOUIS G. BRIZZOLARA

A typical case of Jeghers' syndrome has been presented. There is controversy as to whether or not patients with this syndrome should undergo repeated laparotomies for removal of asymptomatic polyps as soon as they are demonstrated radiologically. An answer to this problem is not apparent at present.

Fatal Perforation of the Thoracic Aorta by a Gastric Ulcer. A Late Complication of Esophageal Resection 878

CECIL M. COUVES, JOHN M. HOWARD AND J. RICHARD AMERSON

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BOOK REVIEWS 882

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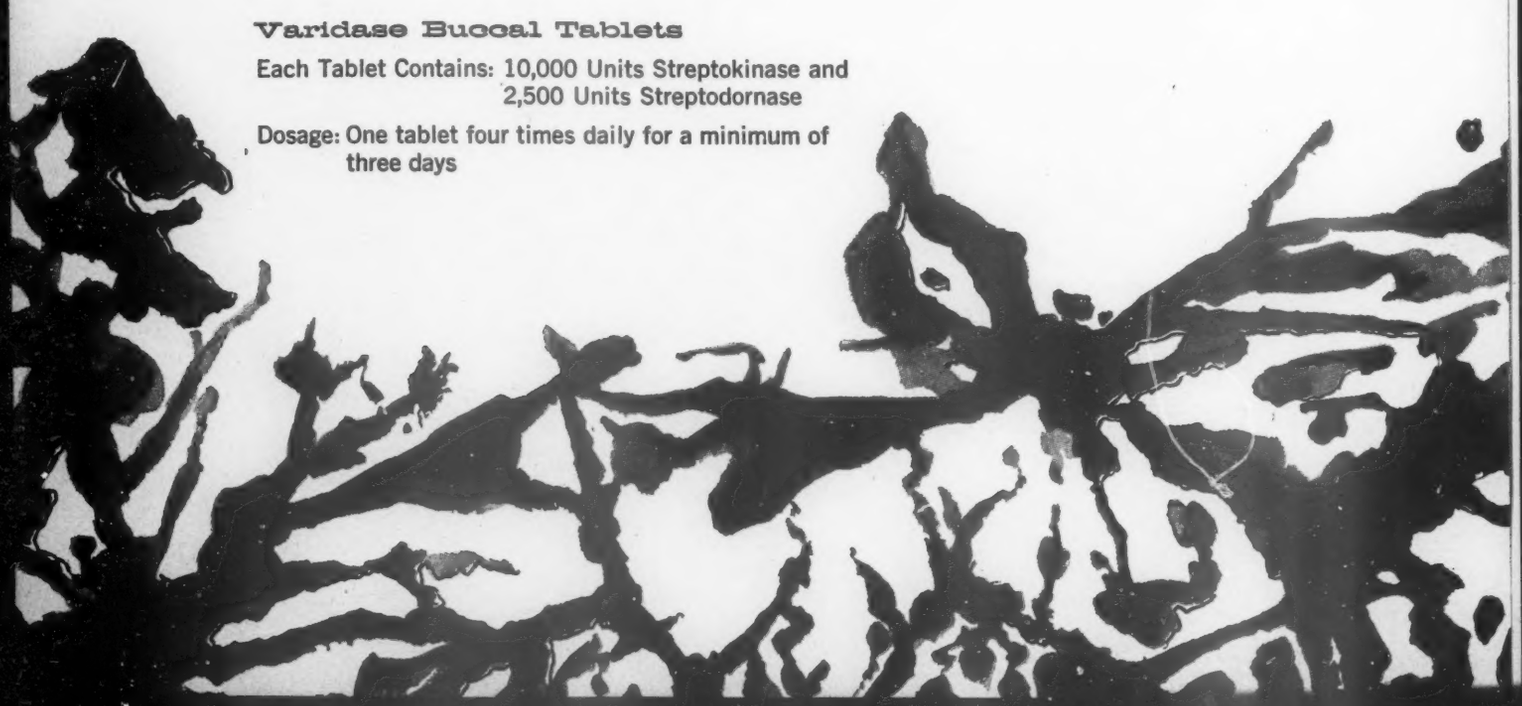

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*Miller, J. M.; Godfrey, C. C.; Ginsberg, M., and Papastrat, C. J., in Surgical Service, V. A. Hospital, Fort Howard, Maryland: Postgrad. Med. *22*:609, 1957.

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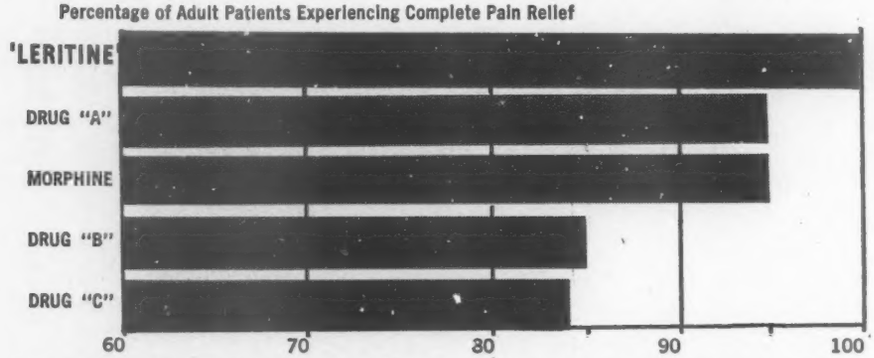
CHART 1: COMPARATIVE RELIEF OF POSTOPERATIVE PAIN (3-Day Period)

Percentage of Adult Patients Experiencing Complete Pain Relief



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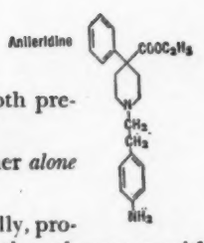

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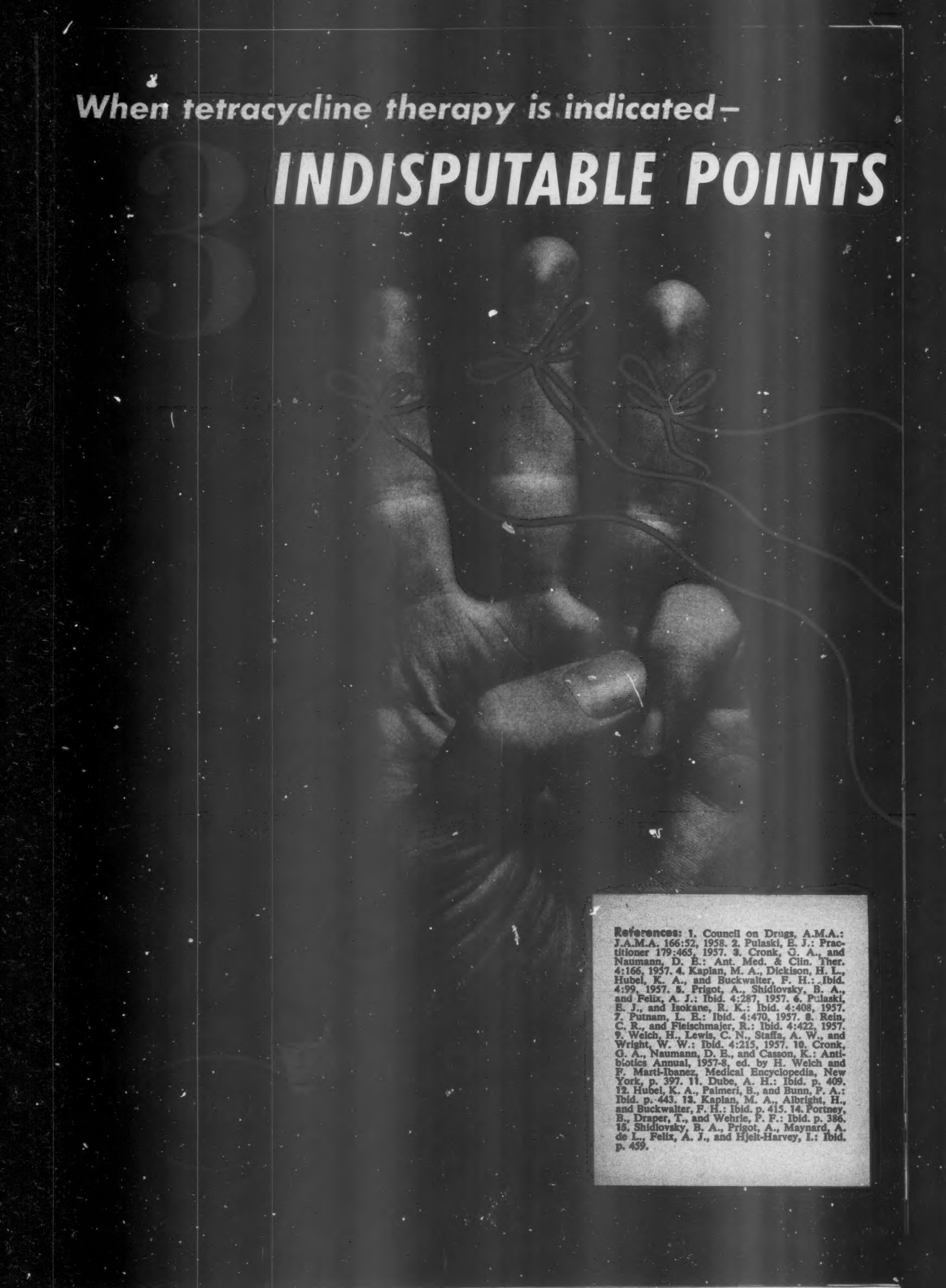

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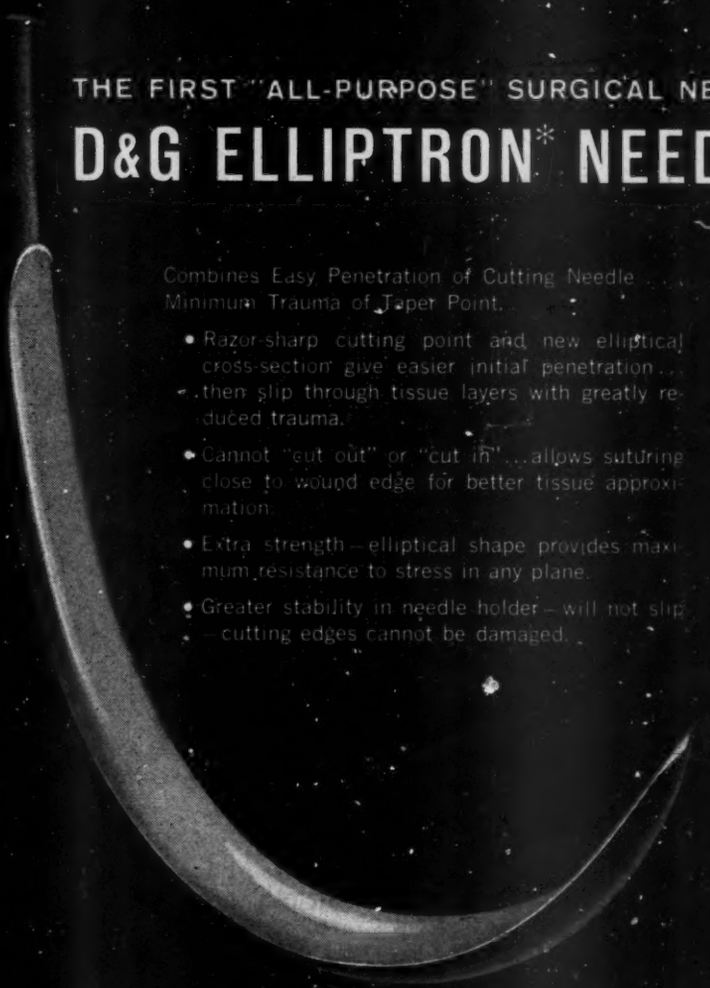

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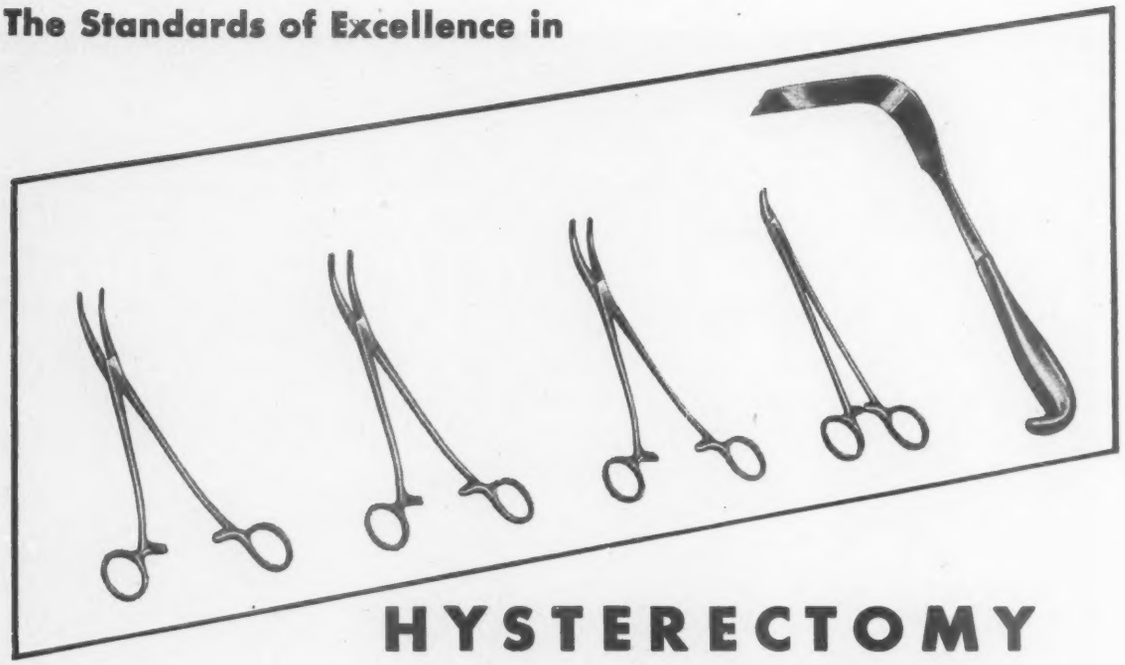

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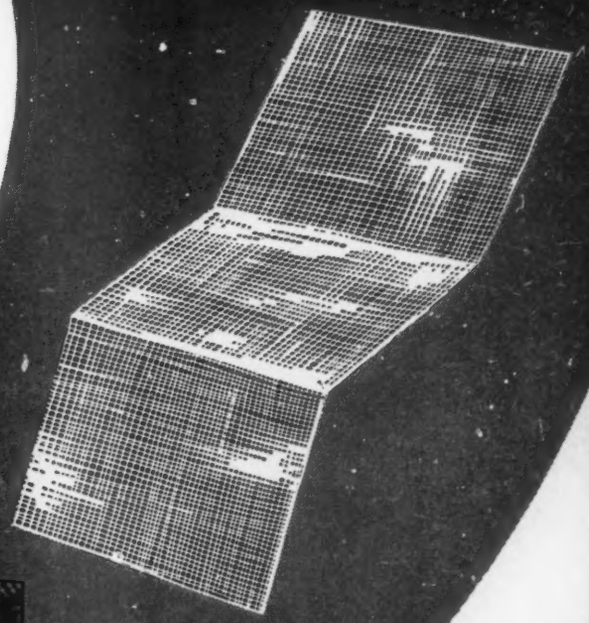

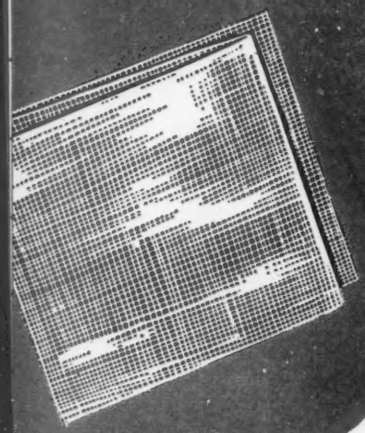

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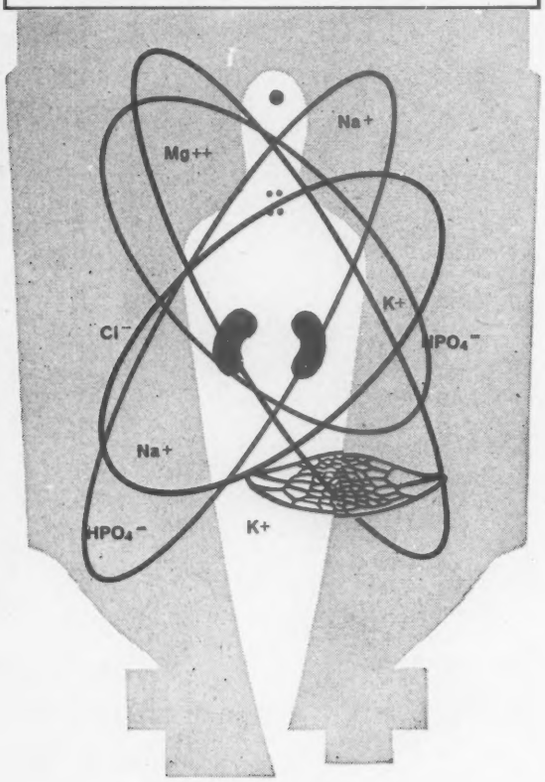

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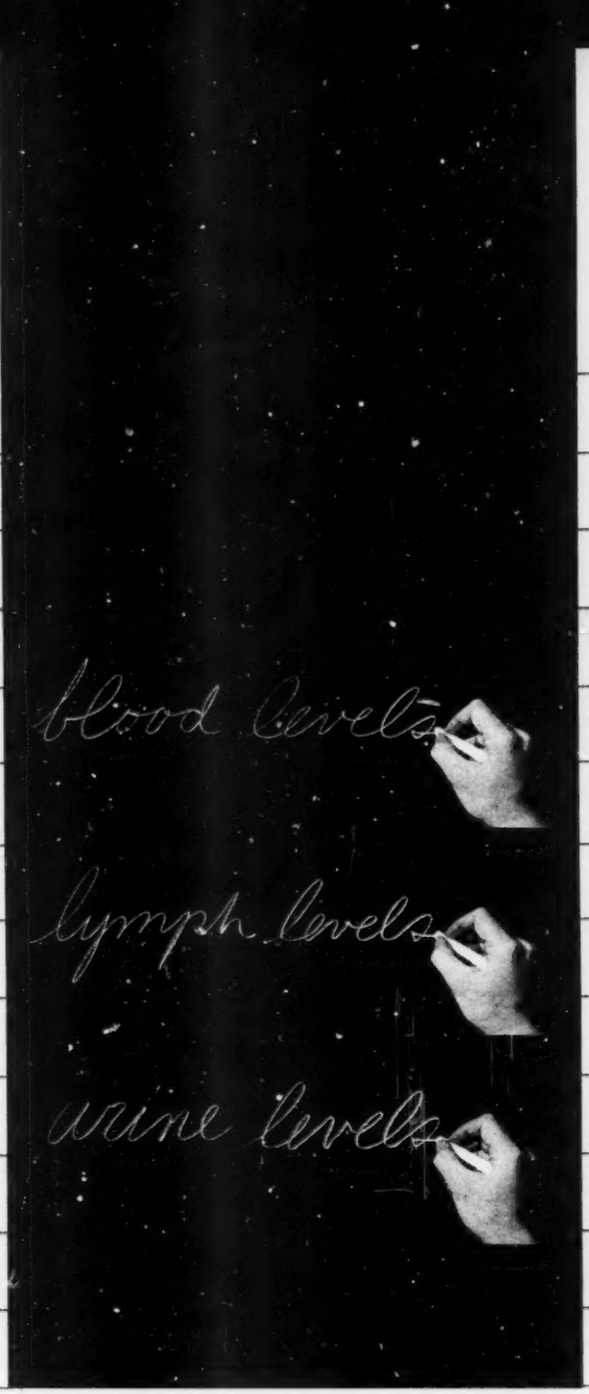

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The American Journal of Surgery

VOLUME 95 MAY 1958 NUMBER FIVE

EDITORIAL

Cardiorespiratory Resuscitation

GENERALLY speaking, up to the end of World War I, respiratory resuscitation in this country implied artificial respiration. In 1913 Chevalier Jackson urged endotracheal insufflation to supplement manual artificial respiration. In 1928 Jackson's suggestion was revived in the announcement of new equipment for the treatment of asphyxia neonatorum.[1] In May, 1933, as the result of the First Conference of the Society for the Prevention of Asphyxial Death, Inc., now known as the National Resuscitation Society, Inc., wide publicity was accorded the over-all problem of asphyxia, with emphasis on endotracheal insufflation. The *Journal of the American Medical Association* devoted sixteen columns of abstracts to this event, and released an editorial (Current Comment) on July 29, 1933, which concluded as follows: "The Journal has deprecated repeatedly the formation of special societies for every tiny phase of medical investigation and practice; nevertheless this new organization (S. P. A. D., Inc.) may serve an especially useful purpose in meeting a trend in medical practice that cannot be met in any other way." In 1938 the Committee on Asphyxia of the A. M. A., in a questionnaire sent to the department of obstetrics in each medical school in the United States, stressed a classification of the stages of asphyxia, citing specific conditions in which laryngoscopy and intubation should be used. During the past fifteen years the technic of laryngoscopy, endotracheal suction, intubation and endotracheal insufflation, has, for simplicity's sake, become known as "Flagging."

[1] FLAGG, P. J. Treatment of asphyxia in new-born; preliminary report of practical application of modern scientific methods. *J. A. M. A.*, 91: 788–791, 1928.

CARDIAC RESUSCITATION

Shortly after World War II, increased attention was directed to the failure of the heart, ventricular fibrillation and cardiac standstill. Following the pacemaker and countershocks to overcome the effects of fibrillation came the dramatic suggestion that the thorax be opened at once and that manual massage of the heart be instituted without delay. The impact of this suggestion was promptly reflected in the medical and lay press. By this time the postoperative hazards of infection were minimized by the newly discovered antibiotics. It is presently considered quite proper to open the chest of a dying patient without regard to the sterilization of the surgeon's hands or of the patient's chest. Lay press releases have brought about acceptance of the procedure by the layman, thereby eliminating an important deterrent. For example, a woman undergoing a routine physical examination presented an unusual scar on the left wall of the chest. Asked to explain, she replied quite casually, "Oh, I was having an intravenous anesthetic for a D and C. My heart stopped and it had to be massaged."

The number of cardiac arrests and fibrillations treated by open chest surgery appear to be on the increase. Whether these cases have occurred in the past and have been neglected or whether they are actually occurring more frequently is difficult to determine. In any event the potential hazard has now come to be accepted as real by many surgeons whose immediate and direct reaction has been to learn how

to meet it by surgery, assisted by drugs and defibrillation equipment.

If it is true that nine of ten cardiac arrests occur because of hypoxia induced by anoxic, anemic, stagnant and histotoxic anoxia, why should hypoxia be permitted or tolerated? In response to a statement that 90 per cent of all cardiac deaths were due to hypoxia, Claude S. Beck of Cleveland states, "There are two ways that the heart stops beating: (1) fibrillation and (2) standstill. Fibrillation is due to faulty distribution of oxygen within the heart. It is not due to inadequate oxygenation, but it is due to checkerboard distribution. Hypoxia is, therefore, not related to this type of death, but for all other conditions, hypoxia produces death. Once you get away from heart disease, most deaths are due to hypoxia."

CARDIORESPIRATORY RESUSCITATION

Present emphasis on the surgical treatment of cardiac arrest has obscured the fact that cardiac resuscitation is, in reality, a final desperate supplement to respiratory resuscitation. It is not an isolated entity, a procedure which one should be called to face in a normal, well oxygenated heart. Emphasis should be shifted from cardiac massage to the prevention of hypoxia, thereby eliminating much of the need for surgical intervention.

Hypoxia kills at least 50,000 persons a year; cardiac arrest an estimated 5,000.[2] If the greater part of this 5,000 is due to hypoxia, the indications for an intensive effort toward prevention are clear. For those hearts which fail after preventative efforts, skilled cardiac massage through the open chest is mandatory.

There would appear to be no age limit to open chest or transdiaphragmatic cardiac massage. Since the cardiac arrest of the newborn may, in the great majority of instances, be assumed to be of hypoxic origin, massage is indicated when respiratory resuscitation has failed. Ready access to a bloodless field, already "Flagged" and supported by endotracheal oxygen insufflation, offers breathtaking possibilities from a reoxygenated respiratory center. Since the alternative is obviously early burial, what at first glance may seem a shocking procedure will, on reflection, be justified.

The virgin field of open chest cardiac resuscitation of the newborn awaits university research which will offer refresher material on the pathologic physiology of the newborn cardiorespiratory system, an accurate means of diagnosing arrest of the heart and precise recordings of the effect of massage—the whole guided by a conviction that respiratory resuscitation has failed.

Cardiorespiratory resuscitation is presently an "orphan" in the medical school curriculum. The specialties regard it as an uninteresting routine, yet it must carry the burden of a major cause of death on one hand and accept close affiliation with first aid groups on the other. Cardiorespiratory resuscitation must find "a local habitation and a name" in the medical school curriculum if the present "rash" of cardiac deaths is to be reduced.

PALUEL J. FLAGG, M.D.,
New York, New York

[2] HOSLER, R. M., Six years' experience with the Cleveland cardiac resuscitation course. *Arch. Surg.*, 73: 813–819, 1956.

The Osgood-Schlatter Lesion

A RADIOLOGICAL AND HISTOLOGICAL STUDY

B. COHEN,* B.D.S. (Rand), H.D.D.R.C.S. (Edin.), M.S.D. (Northwestern), *London, England,* AND R. W. WILKINSON,† M.B., D.C.H., D.M.R.D., *Reading, England*

From the Departments of Morbid Anatomy and Radiology, Postgraduate Medical School of London, London, England.

THE only aspect of Osgood-Schlatter disease which is not controversial is its diagnosis. It is generally agreed that a persistently painful swollen tibial tubercle in an active adolescent is sufficient ground for the diagnosis. Opinions are about equally divided on the aetiology of the disease; some favour a traumatic basis while others feel that the disease is allied to the osteochondroses. Radiological descriptions have tended to be influenced by the osteochondritic theory. Little has been written about the pathology of the complaint as opportunities for histological examination have been few.

It was on October 25, 1902, before the Suffolk District Medical Society, Massachusetts, that Osgood [*16*] gave his paper entitled "Lesions of the Tibial Tubercle Occurring during Adolescence." The paper was published in 1903 and in the same year, Schlatter of Zürich wrote independently on the same subject [*17*]. The 200 papers written in the subsequent fifty years are an index of the interest and lack of agreement on the nature of this complaint.

Our justification for yet another paper is that in a series of twelve cases treated at Hammersmith Hospital, we have the histological details of seven excised tibial tubercles, and we felt that a correlation of findings might contribute toward a more precise understanding of the essential nature of the condition.

MATERIAL

Of the twelve cases of Osgood-Schlatter disease diagnosed in the period from 1940 to 1954, seven patients were boys and five were girls. Five of the boys were fourteen years of age, one was thirteen and one was twelve. One of the girls was thirteen, two were eleven and one was ten; in one case the age was not stated. Nine patients underwent operative removal of the tubercles, four girls and five boys, one of the boys having both tubercles removed. One girl (J. T.) had, in addition, pain in both heels; x-ray revealed some increase in density of both calcaneal epiphyses but no abnormality of outline. One boy (P. J.), who also complained of pain in the left hip, had a circumscribed osteolytic focus in the greater trochanter which is being followed (at the time of writing) with a presumptive diagnosis of tuberculosis. The records of one patient are untraced.

Otherwise the patients appeared to be normal, healthy children. None was overweight and none showed any clinical evidence of syphilis, tuberculosis or any endocrine abnormality. There was no family history of bone disease.

CASE REPORTS

Case 1. D. A., a thirteen year old girl, had a three-year history of gradual onset of pain over the right tibial tuberosity, made worse by kneeling. There was no history of injury. On examination the right tibial tuberosity was enlarged and tender.

* Present address: Department of Dental Science, Royal College of Surgeons of England, London, England.
† Present address: Royal Berkshire Hospital, Reading, England.

FIG. 1. Case 1. Right tibial tubercle showing bony fragments free in patellar tendon, and considerable soft tissue swelling.

The tubercle was excised with no subsequent complaint.

On radiological examination the apophysis (the descending anterior tongue of the upper tibial epiphysis) was elevated and moved slightly forward. Above the upper border of the apophysis there was a bony fragment lying free in the ligamentum patellae, with an irregular scalloped area in the adjoining apophysis from which this fragment had been avulsed. Considerable soft tissue swelling was present anterior to the tubercle. (Fig. 1.) The bone texture was normal, with no rarefaction, sclerosis or fragmentation. The lower pole of the patella was normal. The other knee was normal clinically and no films were available.

The material received for histopathological examination consisted of a piece of bone and cartilage with tendon attached, measuring 40 by 20 by 12 mm.

Histological examination showed a distinct extensive separation of the anterior rim of the apophysis from the main ossified body of the tubercle. The tendon was inserted into an area of bone and cartilage separated from the rest of the tuberosity by a wide area of dense fibrous tissue. Figure 2 shows the insertion of the tendon into this extensive fragment of bone and the remaining rim of cartilage from which ossification had taken place. The intertrabecular spaces had been invaded by vascular connective tissue blending into less vascular and relatively acellular fibrous tissue. Higher magnification of the bone in this area (Fig. 3) showed that it was the site of considerable cellular activity; osteoclastic resorption was a prominent feature and highly vascular connective tissue occupied the marrow spaces; there was little sign of new bone formation. It was obvious, however, that the bone was vital. The appearance could be satisfactorily explained by postulating avulsion of this fragment as a result of excessive tractive force transmitted through the tendon. Elsewhere the attachment of the tendon to bone was noticeably irregular, a feature ascribed by Cole [4] to traumatic stresses. The possibility that ossification was taking place within the tendon was discounted by the predominance of resorptive rather than osteoblastic activity.

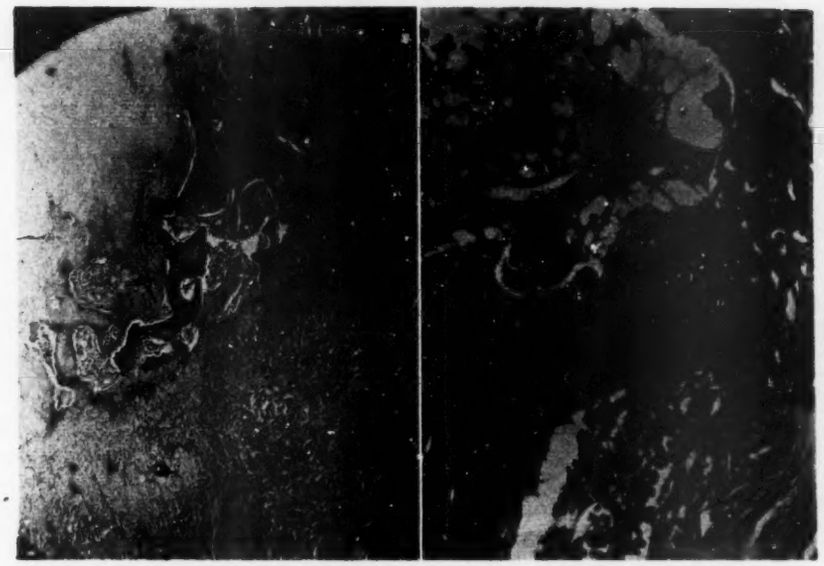
The distinctive feature in this case was the intervention of scar tissue of long standing between bone giving attachment to tendon and that which constituted the bulk of the tubercle. No necrosis of bone was seen. Even the displaced bone is demonstrably vital although the process of reorganisation and repair involves its removal by resorption.

CASE II. J. T., an eleven year old girl, had a one-year history of pain in the left knee and under both heels, made worse by running and eased by rest and supporting bandage. There was no history of injury to the knee. On examination there was slight tenderness over the left tibial tubercle and under both heels. The tibial tubercle was excised with excellent results.

Radiological examination revealed irregularity of the anterior edge of the tibial metaphysis on both sides, more marked on the affected left side. The apophysis was poorly developed in this patient but the largest nucleus for the left epiphysis lay further forward than that on the right side. Several calcified flecks were present above the main nucleus and there was associated soft tissue swelling. The multiple centres of ossification are not to be interpreted as fragmentation but are a normal variant of ossification of the tibial tubercle.

The material received for histopathological examination consisted mainly of cartilage and tendon with portions of bone attached to the latter.

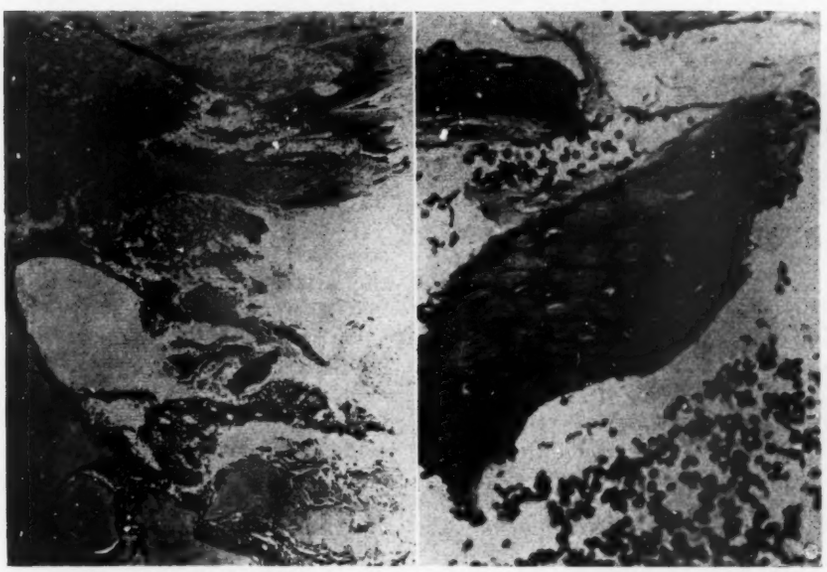
Histologically, the bone was seen to be lamellar in structure. The preservation of cell nuclei, as well as the absence of any marked resorptive process, suggested normal vitality. The continuity of bone had been disrupted in several areas. In one of these the presence of phagocytic cells and early fibrosis indicated that the damage was sustained some time before operation. Bone on either side of this area was normal in appearance. At a different level, separation appeared to have occurred between bone forming from cartilage and bone to which the tendon was attached. A roughly triangular rent was seen, toward the apex of which were signs of



2 3

FIG. 2. Case I. Insertion of tendon into extensive fragment of bone avulsed from main body of tibial tubercle. Original magnification × 35.

FIG. 3. Case I. High power view of bone shown in Figure 2, showing active resorption of dislodged fragment. Original magnification × 400.



4 5

FIG. 4. Case II. Separation of bone to which tendon is attached from cartilage which is undergoing ossification. Original magnification × 50.

FIG. 5. Case II. Fragment of bone lying within area depicted in Figure 4; the appearance is obviously not that of necrotic bone. Original magnification × 400.

recent haemorrhage. (Fig. 4.) Within this area, too, dislodged fragments of bone were evident. Higher magnification showed normal nuclear structure within the cells of these fragments, indicating that they were not broken off from necrotic bone. (Fig. 5.) There was no evidence of ischaemia or bone necrosis in the material examined. The appearance of the tendon was normal.

CASE III. M. T., an eleven year old girl, one year previously experienced onset of pain in the left tibial tubercle coming on after exercise

FIG. 6. Case IV. Left tibial tubercle showing prominent apophyseal downgrowth with "free" osseous fragments anterior to it.

and lasting for five minutes. Afterwards the leg ached after running but there was no actual pain. The tubercle was excised and the follow-up study to four months was uneventful.

Roentgenograms showed the progress of the disease over five months. On the left side there was relatively greater prominence of the tuberosity which had no direct connection with the upper tibial epiphysis and appeared to be fusing with the tibial diaphysis immediately posterior to it. There was a linear streak of calcification immediately above the epiphysis. Soft tissue swelling was present. Five months later union of the epiphysis had progressed further but more calcification was present in the tendon immediately above this area. This gave the appearance of fragmentation described by other authors, but there was no sclerosis or alteration in bone density. The fragmentation was above the area normally occupied by the nucleus for the epiphysis, i.e., it was intratendinous. The soft tissue swelling had further increased. On the right side there was neither soft tissue swelling, fragmentation sclerosis nor tendon calcification. The patella was again normal.

The material for histopathological examination consisted of bone and cartilage measuring 25 by 10 by 10 mm., as well as small fragments of bone.

On examination, it was seen that ossification was proceeding from apophyseal cartilage. A prominent peninsula of new bone formation extended into the main body of cartilage; this ossification, as well as the active remodelling by osteoclasts, was not incompatible with the normal growth. There was no other evidence, at any of the levels examined, of a breach in the apposition of component structures. No necrotic bone was seen. There were no signs of ischaemia; blood vessels were numerous, many of the veins being congested. The attachment of the tendon was irregular, but uninterrupted. Small nests of fibrocartilage were seen within the substance of the tendon. There was however, no evidence of gross damage in the material examined; signs of disordered relationship between component parts of the tubercle could be construed, but not unequivocally.

CASE IV. R. S., a twelve year old boy, had noted pain and swelling below the left knee for a year. The symptoms came on after games and lasted all night. Examination revealed a tender, swollen tibial tubercle. Surgical removal of the tubercle was performed, and six weeks later it was reported that the knee had full function and there was no tenderness or pain.

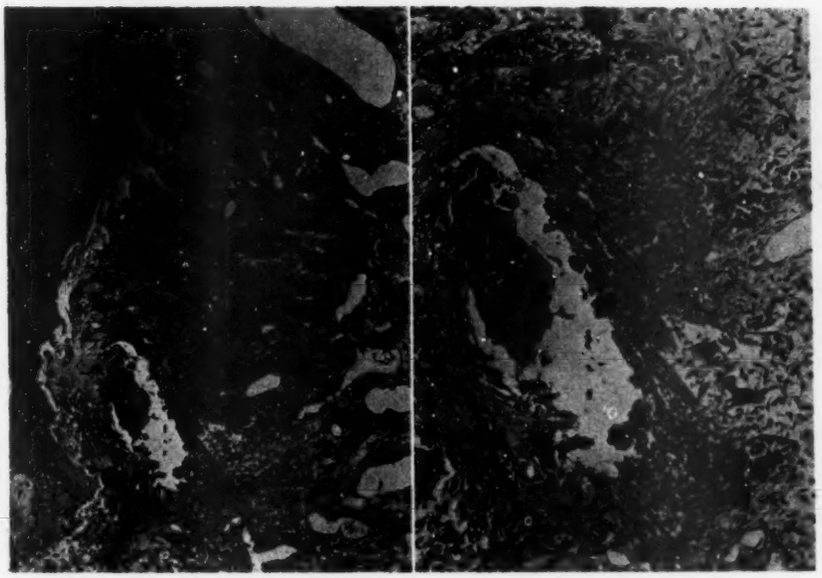
On radiological examination there was a prominent apophyseal downgrowth from the upper tibial diaphysis and a wide gap between the lower part of the apophysis and the tibial diaphysis. (Fig. 6.) There was a large osseous fragment in front of the middle part of the apophysis with several calcified flecks between these two structures and marked punctate erosions of the anterior surface of the apophysis. Soft tissue swelling over the tubercle was marked. Films of the right knee were not available for comparison.

The material for histopatholigical examination consisted of the greater part of the tibial tubercle, the adjacent epiphyseal cartilage and an approximately equal bulk of diaphysis.

On examination, an abnormal area was found to lie between fully formed peripheral bone of the apophysis (into which the insertion of tendon fibres was seen) and a plate of cartilage from which ossification was proceeding. The area was composed of innumerable young capillaries in a stroma of fibroblasts, and was compatible in appearance with repair following separation of the tissues lying on either side. The boundary tissues were normal in appearance and notable for osteoblastic activity.

At a different level two small sequestra were seen which appeared to have been detached from the adjacent bone. (Fig. 7.) Both lay within flourishing connective tissue, and both were undergoing osteoclastic resorption. (Fig. 8.) The adjacent bone from which this fragment was probably dislodged was obviously vital and active bone formation was taking place.

There was no evidence of ischaemia in the material examined. Congestion was marked, probably as a consequence of preoperative manoeuvres designed to reduce haemorrhage. There were no



7 8

FIG. 7. Case IV. Two small sequestra lying within a zone of repair; repair tissue occupies a space between formed bone and ossifying cartilage from which it has been separated. Original magnification × 80.

FIG. 8. Case IV. High power view of one of sequestra shown in Figure 7 illustrating osteoclastic activity surrounding this necrotic fragment. Original magnification × 175.

calcified foci seen in the area of tendon. At the site of attachment of tendon to bone, contact was interrupted by a zone of granulation tissue. The free end of the tendon had fragments of bone attached to it which, when examined with polarised light, appeared to have been separated from the bone of the apophysis. These fragments were undergoing absorption by numerous osteoclasts.

The general appearance of the slides examined suggested that a disruption of the normal relationships of tendon, apophyseal bone and apophyseal cartilage had occurred. There was no evidence of disease preceding this episode and the reaction to it was compatible with normal healing.

CASE V. T. A., a fourteen year old boy, had experienced gradual onset of pain in the left tibial tubercle over the previous two years. A swollen tender tibial tubercle was found on examination. Five months of conservative treatment had no effect. Seven months after the excision of the tubercle he complained of a return of pain in the region of the tibial tubercle, and a tender nodule was palpable in the ligamentum patellae. This was resolved satisfactorily with short wave diathermy.

Radiologic examination revealed a well marked apophyseal component of the tibial tubercle in both knees. On the left side an elliptical bony fragment had been detached from the upper border of the diaphysis; later films showed a well marked bay, shaped to fit the fragment, and the fracture line across the fragment was much more clearly visible. Soft tissue swelling was again present. Again there was no sclerosis fragmentation or porosis. On the right side no abnormality was noted.

The material for histopathological examination consisted of the tibial tuberosity and the insertion of the patellar ligament, together with a fragment of the tibial shaft, the whole measuring 32 by 13 by 13 mm.

The histological picture was substantially similar to that seen in patient D. A. (Case 1). An extensive fragment of bone, into which tendon fibres inserted, was detached from its parent tissue, and the intertrabecular spaces were occupied by cellular fibrous tissue. A view of the detached bone under higher magnification again revealed considerable osteoclastic activity, although the bone which was undergoing resorption showed no sign of necrotic change. These features would be consistent with the appearance of a repair reaction in tissue dislodged by trauma but not otherwise damaged. The healthy state of the bone was evidenced by normal structure and osteoblastic activity in the remainder of the ossifying apophysis. Vascularity was normal.

CASE VI. S. A., a fourteen year old boy, had experienced a gradual onset of pain over the right tibial tuberosity for twenty months. There was

FIG. 9. Case VII. Area of repair lying between bone and cartilage. Original magnification × 30.

FIG. 10. Case VIII. Left tibial tubercle. "Free" bony fragments lying in a bay formed by upper part of tibial tubercle.

no history of injury, and the area was painful only when knocked. The tibial tubercle was slightly swollen. Removal of the tubercle was effective in relieving the pain when the patient was last seen six weeks postoperatively.

On radiological examination the right knee showed a prominent descending apophysis with several bony fragments avulsed from the middle portion. The area from which these fragments had come was clearly visible on an early film. Later films suggested repair; the fracture lines were not as obvious and there was consolidation of the fragments and attempted union with the parent apophysis. This is the reverse of fragmentation. There was no sclerosis, ossification or calcification in the tendon. On the left side appearances were within normal limits.

The material received for histopathological examination consisted of a piece of bone measuring 45 by 15 by 16 mm. and a smaller fragment measuring 6 by 6 by 4 mm.

Examination of the smaller fragment showed normal young lamellar bone. The larger fragment comprised the greater part of the tibial tubercle, partly fused to the shaft. Less cartilage was present than in other specimens of this series. At one level cartilage provided the site of irregular insertion of tendon fibres. There was no sign of orderly ossification of the remaining cartilage, bone being formed in irregular areas, nor were there signs of recent haemorrhage or blood pigment. However, within the apophysis an area of dense fibrous tissue interrupted the continuity of the bone and was compatible in appearance with the counterpart of scar tissue in this locality. No necrotic bone was seen.

CASE VII. K. C., a fourteen year old boy, gave a history of pain over the right tibial tuberosity of four months' duration and over the left tuberosity of one month's duration. There was no history of injury. Both tubercles were excised and the pain disappeared.

On radiological examination the appearances on the two sides were very similar. There was flaking of the anterior aspect of each tubercle. On the right side the flake was irregular, and posterior to it in the main body of the tubercle was an oval area of rarefaction surrounded by sclerosis. There was no fragmentation, calcified debris in the tendon or soft tissue swelling on either side.

The material for histopathological examination comprised two tibial tubercles each measuring 45 by 30 by 20 mm.

Microscopic examination of the left tubercle showed that a broad band of apophyseal cartilage, to which tendon was attached, appeared to have been pulled away from the formed apophyseal bone. Between this cartilage and the bone lay an area of repair, the chief features of which were signs of recent haemorrhage, numerous multinucleated cells lying in close relation to extravasated red corpuscles and a formative fibrosis. (Fig. 9.) There was no sign of any damage to the adjacent bone from which the cartilage appeared to have been separated. It is noteworthy that early ossification was taking place at the free margin of the cartilage. A feasible explanation is that ossification from the cartilaginous plate had resumed after an episode of interruption which, judging by the state of or-

ganisation of the intervening fibrous tissue had occurred some considerable time previously. No such clear-cut lesion was apparent in the material studied from the tubercle of the right side. Apart from an unusual area of vacuolation within the substance of the tendon, the only abnormal feature in this tubercle was an area of fibrous tissue and cellular infiltration interposed between a plate of cartilage and the formed bone. Again there was no sign of vascular damage or of bone necrosis.

CASES VIII to XI. No histological reports are available for these cases.

CASE VIII. Z. A., a ten year old girl, was treated conservatively for six months after the development of a painful tibial tuberosity following injury to the left knee. The tubercle was then removed but the pain did not completely settle until three months later.

Radiological examination again showed partial avulsion of the tubercle with free bony fragments lying in a bay. (Fig. 10.) Soft tissue swelling was present, none of these abnormalities being present on the right side.

CASE IX. No history is available for this female patient (J. M.).

Radiological examination showed a marked linear fragmentation of the anterior aspect of the tibial apophysis. Two calcified flecks were visible in the tendon above the tubercle region. There was no sclerosis but there was considerable soft tissue swelling. In a later film there was some consolidation of the tubercle. On the right side the tubercle was not so well developed and there was irregularity of the cortex in this area. There was no fragmentation or soft tissue swelling.

CASE X. P. H., a fourteen year old boy, when first seen complained of pain over the left tibial tuberosity of fourteen months' duration with no history of injury. He was treated conservatively for three months with little effect and the tubercle was removed. He has had no further trouble with the knee.

Radiological examination showed only soft tissue swelling, there being no bony abnormality.

CASE XI. P. J., a thirteen year old boy, had a history of tenderness, pain and swelling over the left tibial tubercle since being struck with a cricket ball one year previously. The symptoms subsided gradually without interference. He also had had pain over the left greater trochanter where x-ray revealed an osteolytic area. All investigations for tuberculosis were negative.

On radiological examination the knee showed slight soft tissue swelling but no irregularity, sclerosis, fragmentation or tendon calcification. The other knee showed no abnormality.

AETIOLOGY

The aetiology of Osgood-Schlatter disease is a matter of practical importance as well as academic interest. Although the subject of treatment is beyond the scope of this paper, its dependence upon an understanding of aetiology deserves mention. Without a knowledge of the fundamental cause it is only possible to determine the efficiency of a particular line of treatment empirically; too conservative a method may be no more than palliative in effect while, conversely, a procedure which is curative may yet be unnecessarily radical.

The chief point at issue concerns the state of the affected area before the development of the presenting lesion. Many have favoured the view that damage to the tubercle and its associated structures is preceded by underlying disease [*10–12*]. Other writers believe that an uncomplicated and relatively acute injury is responsible for the condition [*3,5,9,13,15,20,22*].

The painful tibial tubercle of adolescence had been recognised for more than twenty years before the papers of Osgood and Schlatter heralded its recognition as a distinctive clinical entity. King [*12*] quotes several relevant articles written toward the end of the nineteenth century. Osgood's paper [*16*] was based on radiological as well as clinical evidence, in addition to experimental dissections on cadavers by which he showed that even if the patellar tendon attachment to the tubercle were severed, the lateral expansions of the tendon into the ligaments of the knee joint sufficed for effective extension. He believed that invalidation of the attachment from the patella to the tubercle was the chief feature, and damage to the tubercle could present as a complete fracture (which he regarded as rare) or, more commonly, as an incomplete avulsion. His x-rays show separation of the tubercle from the shaft and ossification within the patellar tendon. It is to be emphasised that Osgood made no mention of underlying disease. Schlatter [*17*] arrived independently at the same conclusions, although five years later [*18*] he had so far revised his views as to consider the possibility of a growth anomaly being an aetiological factor.

Since 1903 the concept of the lesion as outlined by Osgood and Schlatter has been con-

siderably altered. To refer to the condition as a disease rather than a traumatic lesion was certainly not justified by their accounts. Thompson and Dickinson [21] ascribe the origin of the term "Osgood-Schlatter disease" to a Japanese author. The acceptance of the condition as a form of osteochondritis is less easily explained.

In the subsequent decade several of the true osteochondroses were first described and, perhaps because of its slightly misleading appellation, Osgood-Schlatter disease came to be included within the group. King [12] ascribes to certain French authors the early acceptance of the essential similarity of the various forms of osteochondritis. He, too, is apparently committed to this viewpoint, for he classifies Osgood-Schlatter disease together with Legg-Calvé-Perthes disease and Köhler's disease as a disease process occurring during the period of growth; he believes that trauma is not a factor of importance in the aetiology. There can be little doubt that misconceptions concerning aetiology could arise from the tendency to include Osgood-Schlatter disease automatically within the wide group of conditions variously referred to by different generic terms such as osteochondritis or aseptic necroses of bone. Goff [6] has recently drawn attention to this error. In his exhaustive treatise based on the study of the Legg-Calvé-Perthes syndrome, he refers to true and false osteochondroses; in the former type the fundamental lesion is an occlusive vascular phenomenon, while in the false osteochondroses (among which he includes Osgood-Schlatter disease) trauma is the essential aetiological factor. In addition Goff has observed that true osteochondroses occur only in what Keith and Arey describe as pressure epiphyses; the tibial tubercle, according to this classification, is a tension epiphysis.

Various possibilities have been explored to account for the development of the lesion. Tuberculosis, syphilis, rickets and endocrinopathies have all been investigated. These have been discarded but there remains, as King's writings exemplify, a seeming reluctance to accept uncomplicated trauma as an explanation. Ketelbant [11], although accepting the suggestion that excessive muscular action transmitted through the patellar tendon is the direct cause of the damage, believes that the tubercle has previously been altered in some way by an unknown process. Likewise, Jentzer and Perrott [10], in a histological study of four cases, concluded that the condition is due to patholigical fracture of a "dystrophic" tubercle.

Ollerenshaw [15] reported thirty-two cases and Osgood, who was present at the later discussion, agreed with him that trauma was the responsible aetiological factor. There have been many other papers to support this view. None perhaps expresses it more cogently than Watson-Jones [23] who stated, "It is not a disease. It is a simple traumatic condition comparable to separation of the epiphysis of the os calcis by the tendo Achilles. . . ."

In this investigation we sought to clarify the question of aetiology by a study of case histories and of radiological and histological appearances. Radiological examination offers valuable help in this problem in three ways. First, it gives an opportunity to observe the sequence of events in the tubercle during the progress of the disease. Second, it helps to exclude infective and neoplastic processes with their characteristic sequelae, and third, it makes possible a comparison with the tibial tubercle of the unaffected knee.

Histological examination, apart from confirming the existence of the lesion, can contribute to an understanding of aetiology in two ways. First, the presence of old degenerative change would provide evidence of primary disease following which any traumatic effects might be a secondary event; second, the presence of uncomplicated reparative changes in altered regions would afford evidence of normal reaction to acute damage.

The observations presented herein are positive in the latter respect but negative in the former. Positive evidence of altered architecture within the tibial tubercle complex can be adduced from most of the specimens studied, together with positive signs of reparative changes. On the negative side, failure to identify processes of a degenerative nature must be recorded.

The histological features therefore support the belief that trauma is a primary aetiological factor and negate the hypothesis that the tubercle has been inherently weakened by preceding disease. The disruption of normal appositional relationships between tendon, cartilage and bone is a feature supporting the concept that the damaged complex has been subjected to excessive force. The fact that trauma was mentioned in only one of the case histories

is not necessarily important since minor injuries during active adolescence often pass unnoticed; moreover, the history of the disability invariably extends over many months so that the traumatic incident may well have been forgotten by the time the history is taken.

RADIOLOGY

The necessity of close correlation of the clinical examination with the x-ray findings is stressed by several authors including Osgood. Caffey [*25*] remarks that variability in the size, shape and texture of tibial tubercles in different persons and in the same person on the two sides warrants considerable reservation before a diagnosis of fracture or Osgood-Schlatter disease is made. Most descriptions of the radiographic appearance are influenced by preconceived notions of aetiology and attempts to reconcile the x-ray findings with those of the other osteochondroses such as the Legg-Calvé-Perthes syndrome. We also believe, as does Steen [*19*], that insufficient emphasis has been placed on the dynamic aspect of the disease; if the limb is not immobilised the tubercle is subjected to repeated minimal trauma, and it seems that the radiological appearances may alter with the stage at which the patient is seen. Brailsford [*2*], an authority on osteochondritis, has freely admitted that he has not been able to find the same series of x-ray changes in Osgood-Schlatter disease as he has seen in osteochondritis in other sites. King [*12*] also comments on the difficulty of distinguishing between the normal and Osgood-Schlatter disease, and goes on to give one of the best radiographic descriptions of the complaint. He says: "The tongue shaped process of the upper epiphysis of the tibia has irregular contours and shows intermingled translucent and opaque areas. The process may be displaced anteriorly, but the diagnosis must not be made on this observation alone. The bony portion of the epiphysis may consist of irregularly placed masses of osseous tissue, sometimes in the absence of a shadow of the tubercle itself or at times in addition to the irregular tongue. These masses may be larger, particularly in their antero-posterior diameter, than the tubercle of the opposite side.

"Translucent areas may occur in the form of bays on the surface, of irregularly rounded or oval spots in the epiphysis or of fissures which run either antero-posteriorly or vertically. These last have given rise to the suggestion of fracture. In some cases the translucent areas occur not only in the tongue shaped process but also in the immediately underlying tibia forming bays or fissures on its anterior aspect. As a result of these appearances being associated in various ways, the most diverse pictures are to be seen." Later, after describing the mottled and irregular appearances of the tuberosity, the same author goes on to say " . . . this is distinctive and 'in ideal circumstances' readily separates it from other conditions." The absence of any characteristic picture or sequence of events surely indicates that there are no such things as "typical" radiographic appearances in the disorder.

The definitive tibial tuberosity may be formed from an apophyseal downgrowth from the upper tibial epiphysis or from this together with separate epiphyseal centres, or wholly from a discrete epiphyseal centre or centres which have no connection with the upper tibial epiphysis and which may multiply during growth and development. These features must be kept in mind when radiological confirmation of Osgood-Schlatter disease is sought. We believe that associated with the clinical findings the diagnosis can often be substantiated by adequate and preferably serial radiography, including examination of the unaffected limb. Unlike Brailsford [*2*] we have been unable to find the same changes in the unaffected knee. Several films of varying radiographic penetration may be necessary for a satisfactory demonstration of all the components of the developing tibial tubercle. Enlargement technic using a fine focus tube (0.3 mm.) may prove of value in the further study of the tubercle area.

Like King [*12*] we have found the x-ray picture to be very variable, and can confirm most of his findings. In all of our cases we noted soft tissue swelling anterior to the tibial tubercle. The formation of calcified or ossified fragments in the patellar tendon is common, and it is sometimes possible to note the area on the apophysis from which these fragments have come. Calcified and ossified material is difficult to differentiate radiologically and can only be firmly differentiated when osseous trabeculation can be seen. There may be angulation and swelling of the whole apophysis and occasionally a strain fracture is noted; alternatively the whole tibial tubercle complex

may appear enlarged when compared with its fellow on the opposite side. Although uneven density of the separate epiphyseal centres may be seen, in no case have we noted sclerosis or fragmentation in the region of the tubercle; however, in one case there was linear fissuring of the anterior part of the tubercle which we interpreted with some histological justification as partial avulsion. There was no porosis or evidence of effusion into the knee joint. The patella was normal in all of our patients. In particular, avulsion of the inferior angle (Sindig-Larsen disease) was not seen. In only one instance (patient J. T.) was there clinical evidence of osteochondritis in any other part of the body; there was pain in both heels and radiologically increased density of both calcaneal epiphyses. We believe that the radiological changes due to infection or new growth are entirely different from those seen in the series of patients described herein; in fact these diseases must be extremely uncommon. We can quote only one instance (Köhler [*26*]) in which infection, due to tuberculosis, has been mentioned.

It may be argued that the appearances we have seen and described are different from those generally accepted as fulfilling the x-ray criteria of Osgood-Schlatter disease and conform more to those of injury, although in only one case was there a definite history of trauma. All of the patients were confidently diagnosed clinically as having Osgood-Schlatter disease, and we believe this is sufficient justification for their inclusion in the series. (Brailsford [2] stresses the importance of the clinical findings compared with the radiological appearances.) Because we believe that injury is the real basis of the disease, we think that a classification of the radiological changes such as that suggested by Kridelbaugh and Wyman [*13*] serves no useful purpose.

HISTOLOGY

So far as a histopathological study is concerned, two major difficulties confront the investigator. The first is a technical problem arising from the examination of bulky specimens of a hard tissue. It is necessary to examine microscopically the patellar ligament, the apophyseal cartilage, the apophysis and the tibial metaphysis—severally as well as at their interfaces. In order to accomplish this, numerous sections cut at different levels are required. The second difficulty is less easily overcome. So many confusing descriptions of the pathological features of this condition have been published that an array of different manifestations must be sought in each section. In this investigation a list of the microscopic characteristics mentioned by a selection of authors was compiled and searched for systematically in the material available. These features might broadly be classified under three headings: (1) vascular disturbances; (2) changes within the tendon; and (3) damage to bone or cartilage including fracture, avulsion or necrosis of fragments.

The vascular change most frequently referred to is ischaemia. Allusions to an ischaemic state are widely disseminated and, so far as we have been able to ascertain, never substantiated. Bennett [*1*] suggests that because the affected areas of bone are largely surrounded by cartilage and have a limited blood supply, ischaemia is likely to be concerned in the production of the condition and may be the result of trauma. Moritz [*14*] discerns a great similarity between the aseptic necroses (among which he includes Osgood-Schlatter disease) and the histological appearances of necrosis due to inadequate blood supply. He states that ischaemic necrosis of a narrow zone of bone occurs regularly on either side of a line of fracture and that reactive or reparative phenomena cannot develop without the re-establishment of a vascular supply. So far as the possible role of trauma is concerned, Moritz discounts it as a direct aetiological factor, preferring to believe that the effect of any injury is exaggerated because the bone is already diseased (that is, ischaemic). It is asserted that "there is a period early in the disease when the lesion is symptomless and unrecognized"—a statement which cannot withstand scrutiny. Weinmann and Sicher [*24*] also lay claim to the existence of an ischaemic factor and go so far as to suggest that a neurovascular injury might be initially responsible. However, no evidence is produced by these authors in support of their contention. Hirsch [*8*] describes a reduction in size of the lumina of nutrient arteries as a characteristic feature seen in aseptic necroses. Cole [*4*] differs from those authors previously mentioned in that he regards an increased blood supply as the noteworthy vascular change; he reports this as occurring both

within the tendon and in the area of junction between the tendon and the tuberosity. Uhry [22] alone, of the authorities mentioned herein, explicitly refutes the existence of specific vascular changes.

Changes within the tendon are regarded as an important feature by Cole [4]. The foremost of these, he states, is the formation of areas of fibrocartilage which tend to calcify and later to ossify; they owe their origin to the effects of trauma. Microscopically, the fibres of the tendon are said to be loosely arranged with increased vascularity and patches of fibrocartilage replacing normal tissue. The attachment of the tendon to the tubercle shows irregularity and altered form, a zone of fibrocartilage intervening between the tendon and the tubercle. There is great vascularity in this area with infiltration of chronic inflammatory cells. One of the more detailed papers on Osgood-Schlatter disease, that of Hughes [9], provides considerable evidence of deranged structure within the tendon. Hughes regards the pathological changes in this disorder as being akin to those seen in myositis ossificans occurring in the tendinous fibres of the brachialis muscle. He concludes that since Osgood-Schlatter disease occurs primarily within the tendon rather than the apophysis it is a tendinitis rather than an apophysitis. In a series of seventeen cases he reports the occurrence of ossification within the tendon either at the site of its insertion into the tibial tuberosity or at a higher level, or at both these sites. Like Cole, he believes that trauma instigates the osseous change, either by provoking an extension of the osteoblastic reaction from the bone or by initiating osteoblastic metaplasia of fibroblasts within the tendon. Harbin [7], in suggesting that the condition may be a tendinitis ossificans rather than a true osteochondrosis, refers to evidence that the primary lesion may be a partial tearing of the patellar ligament.

There are several adherents to the belief that Osgood-Schlatter disease is primarily a disorder of the osseous structures proper rather than of the ligament or associated soft structures. The anatomy and development of the tibial tuberosity is such that its vulnerability seems unquestioned. A comprehensive account of these aspects is provided in the valuable paper of Hughes [9]. Until the age of six years, development of the tuberosity has not commenced. From that time until approximately fourteen years it constitutes an apophysis distinct from the tibial shaft, and, until complete fusion obliterates separation from the diaphysis, the tuberosity constitutes a beak of young bone to which are transmitted, through the medium of the patellar tendon, formidable tractive forces. As Osgood stated in his original paper [16], "to the tip of a tongue-like process of bone, or to a separate bone centre, is attached the tendon of one of the most powerful muscle groups in the body." It is not difficult to imagine that violent extension of the quadriceps muscle could indeed result in partial fracture or avulsion of the apophyseal beak; this is just such an eventuality as might be expected in the type of patient in whom the condition is most commonly seen—the robust and athletic adolescent. Whether such fragmentation does in fact occur as a constant feature of Osgood-Schlatter disease could only be established if the existence of such traumatic effects were demonstrable microscopically in affected tubercles.

Weinmann and Sicher [24] state that such fractures do occur, but believe that they run through bone which has already been rendered necrotic as a result of ischaemia. This latter view is shared by Bennett [1], who states that in the early stages of Osgood-Schlatter disease one may note the disappearance of osteocytes from bone trabeculae but little change in architecture. Later, as the bone becomes necrotic, it may crumble and collapse, although the overlying cartilage which is nourished by synovial fluid remains viable. These concepts of damage to bone already rendered weak have no part in Osgood's understanding of the condition which has come to bear his name. He attributed complete or partial disruption of the apophyseal complex to sudden violent contraction of the quadriceps extensor. Many years later Uhry [22] reiterated the concept that trauma is the predominant factor underlying Osgood-Schlatter disease, and offered as an explanation of the derangement the forcible separation of any two or more of the structures comprising the tibial tubercle complex. He does not subscribe to the belief that underlying disease processes have rendered the tubercle constitutionally inferior. "Inflammatory, endocrine, vascular or other specific changes are not in evidence. There

seems to be no factor predisposing towards the condition other than the normal weakness of the part and its relative inadequacy to the exigencies of function and poor resistance to trauma at a time of life (usually puberty) when the disorder appears. The immediate instigating factor is consistently trauma."

In the present study nothing has been found to support the belief that vascular disease or bone necrosis precede injury to the tubercle. On the contrary, the absence of any sign of underlying disease and the presence of extensive repair in many of the sections examined affords strong evidence in support of Uhry's concept. So far as the tendon is concerned, some of the features mentioned by Hughes [9] and by Cole [4] were found in certain cases; however, in view of the small amount of tendon included in the material available, the value of histological observations in this respect is limited.

SUMMARY AND CONCLUSIONS

1. Eleven cases of Osgood-Schlatter disease are presented in seven of which histological examination of the tubercle was possible.

2. There is no justification for regarding this condition as an aseptic necrosis of bone nor should it be grouped with the osteochondroses.

3. The distinctive features emerging from radiological and histological examination suggest that this condition is essentially the result of a dislocation of appositional structures within the tibial tubercle complex; that this dislocation is not preceded by underlying disease; that it is followed by repair reactions; and that its origin can most feasibly be ascribed to trauma.

4. We consider the term Osgood-Schlatter disease a misnomer. If the eponym is to be preserved, Osgood-Schlatter lesion would be a more accurate term, and less misleading.

Acknowledgment: Our thanks are due to Mr. C. Gray, for access to the case papers of these patients admitted under his care; Dr. I. Doniach, Professor C. V. Harrison and Dr. R. E. Steiner, for much advice and encouragement; Mr. R. Brecknall and his staff for the x-ray reproductions; Mr. J. Griffin for the sections and to Miss R. Klein for the photomicrographs.

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Coronary Heart Disease

THREE DOMINANT CAUSES OF DEATH

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OUR experience with coronary heart disease is based upon approximately 6,000 experimental operations on the coronary blood vessels of dogs in the past twenty-five years and, since 1935, about 500 operations on patients with the disease [1]. The combined experiences from the laboratory and from the operating room have helped us to analyze the complex nature of coronary heart disease and perhaps add some new light to the subject. We have asked ourselves many questions which we have tried to answer on the basis of our experience [2]. We have produced some new physiology and some new clinical concepts concerning the disease which appear to be reasonable [3]. We have analyzed the dominant factors producing death; we have identified these factors and we know the nature of effective treatment of each. Clarification of any one of the many facets of the disease is a step in the right direction.

THREE DOMINANT CAUSES OF DEATH

These are (1) the production of an unstable electrical condition in the heart; (2) the reduction of total coronary artery inflow; and (3) destruction of muscle. In most instances there is one dominant factor with one or both other factors in a recessive position. Recognition of the dominant factor producing death is important because it must be recognized first before it can be analyzed. Without this separation of factors there is no focus for analysis. This classification does not include complications such as rupture of the heart and aneurysm of the heart.

Oxygen Differentials, Electric Instability, Anginal Pain, Fibrillation. Uniformity of oxygenation in the heart muscle is accompanied by electrical stability in the heart. A uniformly and well oxygenated heart is electrically stable. A uniformly and deeply cyanosed heart is also electrically stable. The amount of oxygenated blood delivered to the heart is not a factor in its electrical condition. An uneven distribution of oxygen is accompanied by electrical instability. Electrograms taken from the surface of the heart are identical for the pink heart (uniformly well oxygenated) and for the blue heart (uniformly and deeply cyanosed). When pink and blue areas of myocardium are in juxtaposition the S-T segment is elevated over the cyanosed muscle and depressed over the well oxygenated muscle. These alterations were determined in the presence of a blue island of muscle in a pink heart and also a pink island of muscle in a blue heart. These patterns indicate the production of electricity between the pink and blue muscle. These are not currents of injury as the physiologists have labelled them. Cyanosed muscle is not injured muscle. They are currents of oxygen differentials. These currents produce anginal pain and the fatal heart attack. When they become strong enough to fibrillate the heart, they cause death. In our research laboratory we refer to this physiological phenomenon as "pink and blue in the heart" or as a "checker-board distribution of blood in the heart." The total inflow of blood is adequate but the distribution is uneven. The heart does not need additional blood from outside sources. (Fig. 1.) It needs an even distribution of what it gets.

Inadequate Total Coronary Artery Inflow. The coronary arteries may be so severely stenosed that the amount of blood delivered to the heart is not enough to sustain the beat. If the distribution of inflow is uniform so that fibrillating currents do not destroy the heart

beat, then the stenosing process can become so severe that the muscle loses its power of contractility although the muscle remains viable. (Fig. 2.)

Destruction of Muscle. Muscle undergoes infarction when it is deprived of its blood supply. The process of destruction may proceed without producing electric currents of

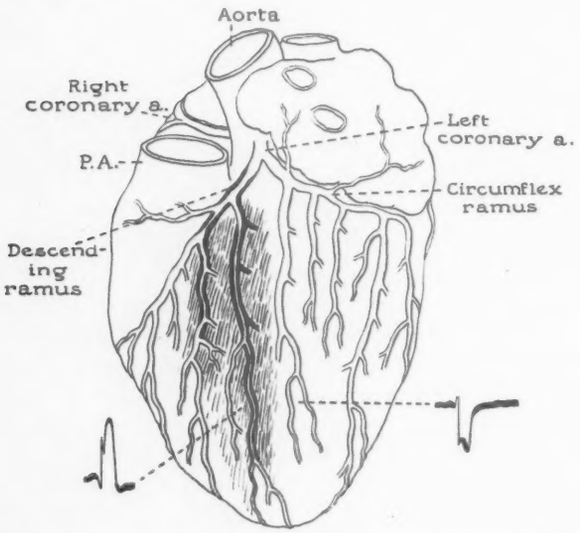

FIG. 1. Two branches of the descending ramus of the left coronary artery are stenosed. This produces an oxygen differential in areas of myocardium that are in juxtaposition with elevation of the S-T segment over the cyanosed area and depression over the well oxygenated area. These currents may become strong enough to fibrillate the heart; the heart electrocutes itself. The heart is too good to die. Death can be prevented by a more even distribution of blood. The heart receives enough blood. Intercoronary channels bring about a more even distribution of blood and these can be produced by surgery.

fibrillating capacity. The destroyed muscle may be a large area or many small areas. As one artery after another becomes occluded, the condition occurs when there is not enough contractile muscle left to circulate the blood and the heart fails. The total coronary artery inflow is adequate to support the heart beat. Some areas of muscle receive more blood than necessary and other areas receive less than enough to preserve viability of muscle. The patient dies a muscle death, in cardiac failure. (Fig. 3.)

Failure to Convert Energy. The heart may fail to convert its energy-producing substances into mechanical energy. This failure is not restricted to coronary artery disease. The heart stops in asystole. Blood supply and muscle both seem to be adequate and there are no fibrillating currents. This type of death is not included in this discussion.

OXYGEN DIFFERENTIALS, ELECTRIC INSTABILITY, FIBRILLATION

The concept of electric instability produced by oxygen differentials is fundamental. This

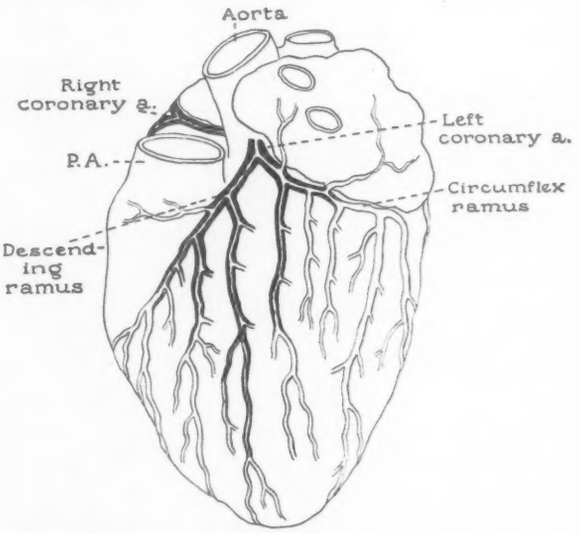

FIG. 2. The coronary arteries are stenosed to such a degree that the inflow of blood is inadequate to support the heart beat. Distribution is even so that there are no fibrillating currents and there may be no infarct. Effective treatment requires additional blood plus intercoronaries for distribution. The heart resists additional blood.

condition can be readily produced in the experimental laboratory. It may or may not have fibrillating capacity. If so, it causes death. This electric instability is independent of total coronary inflow. Total inflow may be adequate; one area of muscle is better oxygenated than another area in juxtaposition. The mechanism of oxygen differentials producing electric instability is not the same as the mechanism that destroys muscle. That the electrical condition is a death factor has been established beyond a reasonable doubt. I have successfully defibrillated several human hearts that fibrillated because of this condition. This death factor may be a small one and we have shown it to be reversible by restoration of the coordinated heart beat and complete recovery of patients. Up to the present time there has been little understanding of the relationship between currents and infarct. The term "myocardial infarction" is generally used to designate the

entire subject of arterial occlusion. The term "mild coronary occlusion" is regarded as a clinical entity and death, when it occurs, adds mystery to the loss of a bit of muscle. It is difficult to understand that (1) electricity is produced in the heart; (2) it is not related to infarction; and (3) it can kill. The heart electrocutes itself. This kills more people than the loss of muscle or inadequate inflow.

Treatment of this factor is prevention of the condition. This is accomplished by bringing about an even distribution of blood in the heart muscle. Treatment does not require additional blood from sources outside the heart. In the vast majority of the victims of the disease, there is enough blood in the heart's substance to maintain the beat, and treatment requires an even distribution. This can be accomplished by the production of intercoronary arterial communications; these can be produced by surgical operation. Coronary occlusion produces communications between arteries but for this stimulus to become effective the disease in many instances must change from stenosis to occlusion, and while this is taking place a large number of people die from electrical instability. The number of people killed by this factor probably is tens of thousands each year in this country. The patient with coronary artery disease is in a protected position if he has a set of intercoronaries.

REDUCED INFLOW

As coronary artery disease progresses, the reduction in coronary artery inflow may be more marked in one artery than it is in another, or the entire coronary system may undergo narrowing in about the same degree. If the stenosing process is more severe in one artery than it is in another, then the distribution of blood becomes uneven and an unstable electrical condition is produced. If intercoronary communications are present or if they develop as the arteries become narrowed, then distribution is more likely to be uniform and currents are less likely to form. In dogs we occluded the entire coronary artery inflow except for a lumen of 1 mm. in the circumflex artery. (Fig. 4.) In order to do this, it was necessary to give the heart a good set of intercoronaries before the arteries were taken down one at a time. (Fig. 5.) An inflow through a 1 mm. lumen was enough to keep the dog alive and active. Reduction of inflow can stop the heart without fatal currents or without death of muscle. The incidence of this type of death is probably not high because the stenosing process usually ends with fibrillating currents. From the standpoint of therapy, reduction of total inflow requires more blood. We attempted to

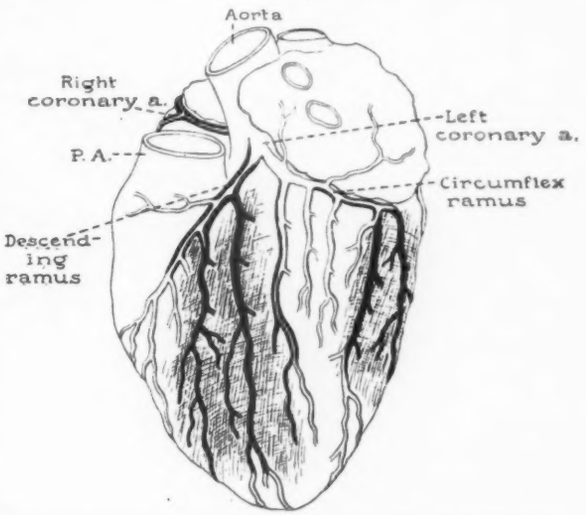

FIG. 3. Several coronary arteries are occluded producing infarcts. The destruction of muscle proceeds to the degree when the muscle fails and the patient dies in circulatory failure. The arterial inflow is adequate to support the heart beat and the currents produced as occlusion proceeded were never strong enough to fibrillate the heart. Destroyed muscle cannot be replaced by any form of treatment. Intercoronaries, if present before occlusion occurs, will reduce the size of the infarct.

provide more blood by using various methods over a period of many years. One method consisted of grafting various tissues upon the heart with the expectation that blood would flow across from the graft to the heart. Occasionally blood vessels large enough to carry blood were demonstrated between graft and heart but usually this was not the case. These grafts protected the heart primarily because the inflammatory reaction on the heart helped to develop intercoronary channels. Another method that we investigated consisted of the conversion of the coronary sinus into an arterial inlet. By this method, blood actually flowed through the capillary bed from the venous side of the circulation for several weeks or for about two months. Then the flow stopped because of intimal thickening in the veins, but while intimal thickening was taking place the heart developed an excellent set of intercoronaries and these protected the heart. On

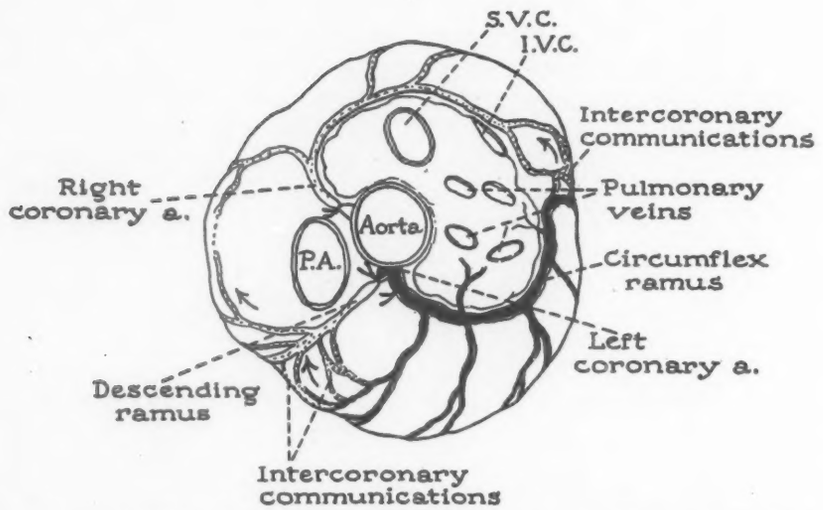

FIG. 4. Hahn-Beck dogs in which all coronary artery inflow was occluded except a lumen of 1 mm. in the circumflex artery. Inflow through a stenosis of 1 mm. was enough to support the heart beat and to make possible normal activity of the dogs. A red cell, once it got by the stenosis, could go anywhere in the heart's substance where it could do the greatest amount of good. Intercoronaries made this possible. Note the ligatures and the intercoronaries.

the basis of our experience, it may be stated that in general the heart resists the entrance of blood from outside sources. Perhaps more effective methods can be developed in the future. Another method for increasing blood

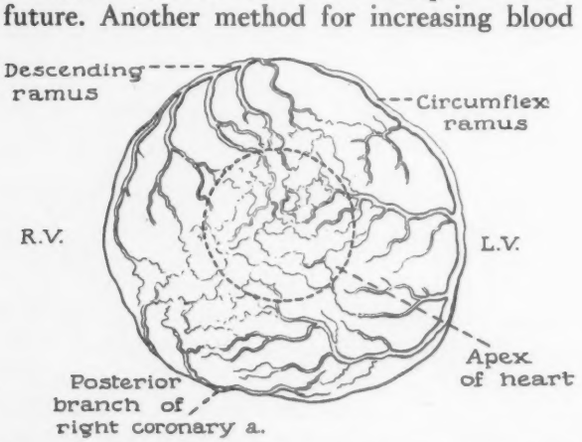

FIG. 5. Artist's sketch of dog heart after author's operation was performed. Note the intercoronaries. These help to protect the heart at the crisis of occlusion. If the heart beat can be preserved for a few days, the stimulus of occlusion comes in to help in the production of additional intercoronaries. The crisis can often be passed in this way and a satisfactory arterial system is established.

supply to the heart consists of a direct approach on the coronary arteries themselves. This approach has been analyzed by us in the laboratory and also in patients with the disease. Easy to understand and attractive as it appears, this method has little or nothing to offer. No less an authority than Mr. C. G. Rob of St. Mary's Hospital, London, stated "I believe that thromboendarterectomy of the coronary arteries is bound to fail because in vessels of this size reocclusion will rapidly occur even with adequate anticoagulant therapy."

DESTRUCTION OF MUSCLE

The third cause of death is by destruction of muscle. Total inflow is adequate to maintain the heart beat. The heart escaped electrical death as the arteries became occluded and remained electrically stable while muscle was destroyed. This type of death was found occasionally in the experimental laboratory but the vast majority of deaths in dogs after coronary occlusion was by the production of electrical fibrillation. The treatment of this condition is the same as that of myocardial failure. Replacement of scarred muscle is not possible.

CORONARY ARTERY INFLOW AS RELATED TO CORONARY ARTERY STENOSIS

The normal coronary arteries can carry large quantities of blood if they are cut and allowed to bleed. Resistance by the arteriolar bed reduces the inflow under normal conditions to about 250 cc. per minute for the human and about 100 cc. for the dog. Not infrequently severe stenosis of all coronary arteries is found

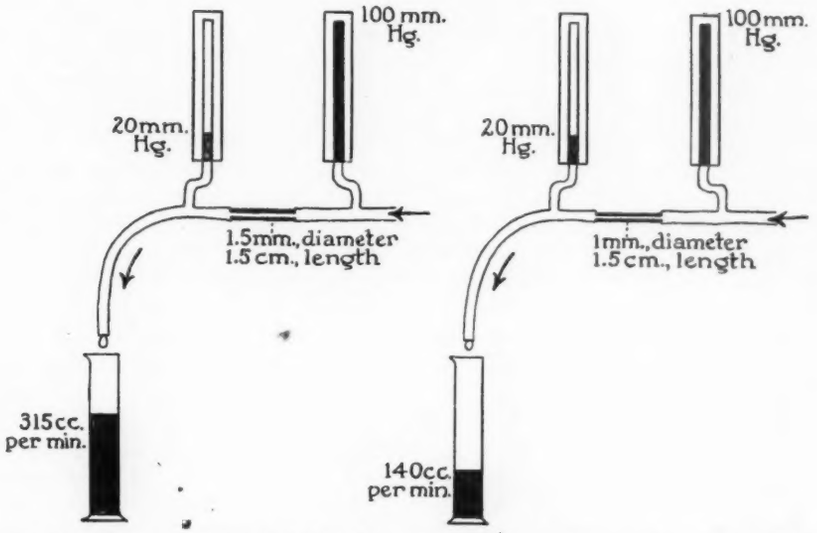

FIG. 6. Artist's sketch of rigid tube system. Inflow pressure is 100 mm. Hg. Outflow pressure (capillary and arteriolar resistance) is 20 mm. Hg. Segments of metal are placed in this system. One is 1.5 cm. in length and 1.5 mm. in diameter; 315 cc. of blood goes through this stenosis per minute; 140 cc. per minute goes through a stenosis 1.5 cm. in length and 1 mm. in diameter. Flow through a normal human heart is about 250 cc. per minute and through a dog heart of average size about 100 cc. per minute. Adequate quantities of blood can enter the heart through severe degrees of arterial stenosis. With good distribution the stenosing process can become very severe before it kills. Emphasis is on distribution.

in human hearts. In a rigid tube system it is possible for adequate amounts of blood to go through a segment of severe narrowing. Thus, with a pressure of 100 mm. Hg for inflow and 20 mm. Hg for outflow (capillary pressure) 315 cc. of citrated human blood per minute go through a tube containing a stenosis of 1.5 mm. in diameter and 1.5 cm. in length; 140 cc. flow through a stenosis of 1 mm. in diameter and 1.5 cm. in length. These quantities are adequate for the human heart and the dog heart, respectively. (Fig. 6.)

Why can the human heart function with such severe degrees of stenosis as sometimes found at autopsy examination? Why can the coronary arteries be stenosed or occluded as in the Hahn-Beck dogs? The correct answer to these questions can be given. The flow through severe stenosis is enough to support the heart beat provided each red cell, after it gets by the stenosis, can go anywhere within the heart's substance where it is needed most. With good distribution death does not occur until the arteries are almost completely closed. With little or no intercoronary distribution death occurs early in the course of the disease and often with slight anatomical change in the heart. These are the deaths that occur on the golf course, while shoveling snow or watching athletic contests, and so on. The heart is too good to die. This is one of the important problems that deserves consideration and has received practically none.

ANALYSIS OF DEATH FACTORS OCCURING IN 200 CONSECUTIVE OPERATED PATIENTS

There were four permanent deaths and one temporary death in the last 200 consecutive patients operated upon for coronary artery disease. The operative mortality rate in the entire group was 2 per cent but in the first 100 consecutive operations it was zero.

Permanent Deaths

Patient 1. During operation the heart showed marked irritability. For several minutes during operation there was no blood pressure, but this recovered and operation was well tolerated. The chest was closed and the patient did satisfactorily in the recovery room. Suddenly and without warning, four hours after operation, the heart fibrillated. The chest was opened, the heart was pumped by hand, oxygen was delivered to the lungs and the patient was returned to the operating

room. The heart was defibrillated and a normal mechanism was restored. The chest was closed. Again the heart fibrillated and again the chest was opened, the heart was pumped by hand, oxygen was delivered to the lungs and the heart was defibrillated. A normal mechanism was restored and the chest was closed. This procedure was repeated a total of four times during a period of eleven hours. During this entire period the brain was kept alive and the patient was conscious and replied to questions. Finally the procedure was stopped although the patient was conscious.

Examination of the heart showed severe stenosis in each of the coronary arteries and no gross infarct. The primary cause of death was reduction of inflow. This explained the loss of blood pressure without fibrillation during operation. Irritability during operation and fibrillation later indicated the presence of currents as a secondary factor. These were produced by operation, but in a heart which was readily susceptible to them. This heart needed more blood.

Patient 2. Operation was performed on November 9, 1956. During operation the heart was irritable and stopped in standstill. The coordinated beat was restored but it remained irritable. Later on it fibrillated. It was defibrillated and a coordinated beat was obtained. After a few minutes it fibrillated again and again it was defibrillated. In a period of four hours it went in and out of fibrillation four times and finally all activity disappeared from the heart. The descending artery was opened several centimeters from its origin. The heart was pumped by hand to produce a pressure. No blood came out of the cut artery. An attempt was made to open the artery with a probe, but this was not successful nor could any of the atheromatous deposits be removed by scraping with a curet. A catheter was introduced into the distal end of the artery and 1 unit of blood was given. No definite response to this was observed.

The arteries were examined. Each major artery was severely stenosed. Extensive infarcts were present. The major factor in this heart was reduced inflow. The muscle was extensively scarified but it probably was still good enough for function. The inflow was probably not evenly reduced and this made the heart unstable. These two factors, reduced inflow and electrical instability, produced the death.

Patient 3. Operation was performed on November 19, 1956. The operation progressed satisfactorily until the heart was elevated from the pericardial sac and the posterior surface of the heart was abraded. The heart abruptly fibrillated. Resuscitation was carried out. The oxygen system was maintained. This consisted of inflating the lungs with oxygen and circulating the oxygen by pumping the heart by hand. The heart was shocked repeatedly. During the next four hours it went in and out of fibrillation about twenty times. Sometimes fibrillation stopped without electric shock. For one period of time the heart had a coordinated beat and a pressure of 100 mm. Hg, but before the chest was closed it fibrillated again. After the situation looked hopeless, the descending artery was opened part way down its course. A probe was introduced through the artery into the aorta. When the probe was removed the heart was vigorously pumped to produce a blood pressure, but only a few drops of blood came from the cut end of the diseased artery. It was not possible to scrape out any of the atheromatous debris from this artery. The heart was pumped continuously except for brief periods when the artery was manipulated. During this entire period of time the patient was conscious; he responded to questions and his brain was viable. After this manipulation on the artery was carried out, a coordinated beat was again obtained and the blood pressure rose to 100 mm. Hg. This time the chest was closed, but the coordinated beat lasted only twenty minutes after the incision was closed. The heart fibrillated again and we gave up.

The heart was examined. The common left coronary artery was patent but both branches of this artery appeared to be occluded, the circumflex 1 cm. from its origin and the descending 2 cm. from its origin. The right coronary artery showed severe stenosis but no occlusion. The muscle showed no gross infarct and would have been able to produce a blood pressure if it had received enough blood and if it had not been disturbed by these currents. The primary death factor was fibrillating currents, but the reduction of inflow through the two branches of the left coronary artery was a secondary factor. Both of these factors produced death.

Patient 4. The fourth death was temporary and will be discussed under another category.

Patient 5. The fifth death occurred on July 17, 1957. This patient went through the operation satisfactorily. On examination of the heart at operation only one branch of the circumflex artery showed disease and there was no superficial infarct. A good prognosis was given on the operative note. The operation was completed at 10:00 A.M. The patient did well in the recovery room. At 2:35 P.M. the heart fibrillated. Within a minute the chest was opened and the heart was pumped by hand. A coordinated beat was established at 3:20 P.M. It fibrillated again at 3:30 P.M. and a coordinated beat was established at 3:45 P.M. The chest was closed. The patient responded to questions

throughout this period of time. After the intratracheal tube was removed, the patient stated that she did not like the electric shocks as she thought they were used only on psychiatric patients. She was able to converse with her family who were brought to the operating room. At 5:30 P.M. the heart fibrillated. The chest was opened. There was no noticeable pulsation in the descending ramus of the left coronary artery and the anterior apical region was acting as a trigger producing fibrillation. My opinion was that the descending ramus of the left artery was occluded. A coordinated beat was restored at 6:30 P.M. and the chest was closed. The patient was conscious and had a satisfactory blood pressure. At about 2:00 A.M. the heart stopped and the chest was opened. The heart was pumped by hand and oxygen was given to the lungs. The patient recognized questions but could not speak because of the tube in the trachea. A coordinated beat was established at 2:15 A.M. and the chest was closed. The heart fibrillated again; the chest was opened and the heart was defibrillated. The chest was closed. The heart fibrillated again; the procedure was repeated. The heart went in and out of fibrillation. Finally no response was obtained from the heart and we gave up at 3:45 A.M.

The heart was examined. The common left artery was patent. The descending ramus was occluded near its origin. The circumflex artery was severely stenosed but not occluded. The right coronary artery was less severely narrowed. An infarct was present in the septum and anterior portion of the left ventricle. The primary cause of death was electric currents which arose from the muscle supplied by the descending artery, and this artery was occluded. Contraction waves were readily observed originating in this area and extending out to adjacent muscle; these in turn were observed to destroy the coordinated beat in the muscle elsewhere. This occurred repeatedly. The primary cause of death was the currents. The secondary cause of death was reduction of arterial inflow, but probably the inflow was still adequate to support the heart beat if it could have been more evenly distributed. The pathology in this heart was not detectable by examination during operation.

Temporary Deaths

Patient 4. Temporary death occurred on May 3, 1957, in a forty year old woman. The heart was exposed. The parietal pericardium was tight on the heart and the amplitude of pulsation was reduced. This suggested acute dilatation of the heart. When the pericardium was opened, the pulsation improved. The only anatomical disease found at operation was thickening of the descending artery near its origin. The operation was tolerated well and a good prognosis was given on the operative note. Four hours after operation the heart fibrillated. The incision was opened and the heart was pumped by hand. Oxygen was given. The patient was moved to the operating room and the heart was defibrillated. The coronary arteries were felt to be thickened when the heart was massaged. This arterial disease was not recognized during operation. The heart was shocked twice before the coordinated mechanism was restored. The chest was closed. The patient was dead for twenty-five minutes. I saw the patient on June 29, 1957. The blood pressure was 120/88 mm. Hg and the pulse rate was normal. The only mental deficit was inability to remember events several hours before and after the operation. On February 20, 1958, at a medical meeting, this patient described the experience of death.

The death factor here was an oxygen differential which produced a current strong enough to fibrillate the heart. This factor was removed and it has not recurred. The probability is that intercoronaries from operation are protecting the heart against recurrence. That there was adequate inflow is indicated by the fact that the patient is alive and active (she now does her own housework). That the muscle is adequate to pump blood is indicated by a normal blood pressure and the absence of failure. The conclusions are that the death factor was a fibrillating current, that it was reversed, that it has not recurred, that life has been restored. The scientist accepts these conclusions and expects further development of the thesis that the death factor may be a small reversible factor. It has been proved experimentally that surgical operation, by the production of intercoronaries, can reduce these currents and the size of the infarct if they are present before the stenosis or occlusion occurs.

Another temporary death is not included in this series because operation was not performed. It is presented here for purpose of analysis. This patient had had several infarcts and was incapacitated because of pain. The heart was not enlarged as determined by x-ray; there were no signs of failure. The patient was anesthetized and an intratracheal tube was inserted. He was connected to the electrocardiogram and turned on his side. The blood pressure, heart rate and electrocardiogram were normal. Suddenly the heart stopped beating; there was no blood pressure, there was no electric activity in the heart and the pupils dilated. The patient was dead. He was turned on his back. Death lasted two to three minutes. I was about to open the chest and try to resuscitate the heart when it began to beat again. The blood pressure and pulse rate returned to former levels and the patient became conscious. Operation was not performed. The most probable cause of death was inadequate inflow.

There were no fibrillating currents because these would have been detected on the electrocardiogram; no signs of muscle failure were present. In the presence of reduced inflow it is possible for such factors as position on the table and a small amount of anesthesia to stop the heart. This patient will not be considered a satisfactory candidate for operation in the future.

DEATH AND RESUSCITATION

It is well known that different parts of the body die at different times. The brain is very susceptible to the absence of oxygen and shows changes if it is without circulation for longer periods than three to five minutes. Under hypothermia this viable period is longer. The heart is viable for longer periods than the brain. The heart beat has been restored in patients after severe cerebral damage has taken place. The Russians used blood from cadavers for transfusion. A tourniquet can be placed on an extremity, cutting off all blood supply for an hour or longer, and viability will be present after it is removed.

The resuscitation procedure consists of two parts. One concerns the re-establishment of the oxygen system before the brain is damaged and the other concerns restoration of the heart beat. The first part consists of delivery of oxygen into the lungs and circulation of this oxygen by pumping the heart by hand. This is the emergency act. The second part is restoration of the coordinated beat from ventricular asystole or fibrillation. This can be done in almost every normal heart and also in a good many hearts that are the seat of disease. In some it is not possible. The resuscitation procedure was designed as something to be done in the operating room but it has been used successfully outside the operating room on hospital wards. It has also been used successfully on persons dressed in street clothes who died within the hospital where hospital facilities were used [5–8]. Whether it can be extended beyond the hospital remains to be seen. The idea of resuscitation outside the hospital when the chest must be opened is offensive to the living, and the dead have no spokesman. Thousands of people are lost each year in this country as though the heart were touched by an "electric wire." Hearts too good to die bring about their own destruction. This is self-electrocution of the heart. To society this problem has scarcely been defined.

The timing of death may create some discussion. The moment of death has an aura of unreality which makes death unacceptable until the living are convinced that there is no hope of recovery. The moment of death starts with the breakdown in the oxygen system. If the resuscitation procedure is used before the brain dies, the death may be temporary, and the death factor may be reversed. In patient 1 the brain was kept alive for eleven hours and the heart beat was restored and lost several times. In patient 3 the death factor might have been reversed during a period of four hours. When we gave up, death became permanent. In patient 5 death was intermittent and recurrent for many hours. The patient talked to her family between deaths, which were temporary, and death became permanent when the resuscitation procedure was stopped. In patient 4 the death factor was reversed successfully by the procedure, and in the other patient who was not operated upon it reversed spontaneously.

The other point of view is to consider death as a permanent condition. In the absence of the resuscitation procedure this attitude is acceptable, but those who make the effort to restore life know that death is not necessarily permanent. They know that life can be restored, and this only by their effort. The weight of experience in the future will time death at the moment when the oxygen system stops. Experience will dictate that the death factor can be reversed and that death can be temporary. These concepts are strange now, but they will not be strange in the future. This attitude places resuscitation in its proper position; the other attitude, which considers death as a static and permanent condition, conflicts with science. According to this point of view, there is no reason to try to resuscitate a person at the moment when the circulation stops because he is not yet permanently dead; if he is not dead by this definition, then he is alive; and, if he is alive, the chest should not be opened and this drastic procedure should not be applied. This attitude negates effort and breaks with science. Nevertheless, it is the prevailing point of view. The high priest and the physician are in accord on the permanency of death because neither makes an overt act at reversal. The physician does not care to be less perfect in his behavior than the priest. Effort involves the possibility of failure. Therefore, to try invites the risk of failure. Not to try is to appear perfect.

COMMENTS

This discussion of death factors leaves much to be desired, but it is presented as a framework for analysis. No scientist will deny that this subject should be analyzed when our knowledge is so defective; when the term myocardial infarction covers the entire subject; when a mild coronary occlusion kills and there is no explanation; when the concept of oxygen differentials is scarcely recognized; when it is not appreciated that the death factor from currents may be reversible; when reduction in inflow is not differentiated from uneven distribution; when the role of intercoronaries is not understood; and when their production is heresy because this breaks custom. The fate of the patient depends upon the amount of blood in the muscle distal to the stenosis or occlusion. This self-evident truth or axiom of the disease has received no recognition in the past, and yet it is elementary and fundamental.

SUMMARY AND CONCLUSIONS

1. Three death factors of coronary artery disease are presented. As the cause of each death, there is one factor that is the most important and either one or both of the other two factors may be contributory. These three factors are different from one another yet they are produced by the same disease.

2. Recognition of these causes of death is important because, first, it helps to clarify clinical aspects of the disease. For example, a mild coronary occlusion that kills is no longer a mystery. Second, recognition brings treatment into clear focus. The question can be asked, what does each death factor require for treatment and the answer can be given. All forms of treatment, medical as well as surgical, are hereby subjected to scientific scrutiny.

3. Analysis of death factors creates a path for future research. This path is properly marked as to where it leads. For example, one researcher may take the one marked distribution of blood in the heart while another takes the one marked addition of blood to the heart. Each leads to important places but in different directions.

4. It is an understatement to say that research in treatment of the disease needs direction. No scientist will deny that the clinican after a lifetime of responsibility in handling this disease should know whether his treatment has increased the amount of blood in ischemic muscle by intercoronaries, by addition from other sources, or not at all.

5. The death factors and the axiom of coronary artery disease seem to be as poorly understood today as were the bacterial diseases before Pasteur. That "a coronary" is a mild affair with nothing to fear and good to have, as we are often led to believe, is reminiscent of the attitude concerning "laudable pus" before the time of Lister. Now that this problem has been stated in terms of simple mechanisms it becomes the responsibility of the clinician to prevent them insofar as this is possible and also to permit and advise the application of the now existing forms of effective treatment when they occur.

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The Replacement of Shaft Defects of Long Bones by Metallic Prostheses

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THE bridging of defects in the shafts of long bones has always been a formidable problem, especially when associated with severe injuries to soft tissue resulting from gunshot wounds. In this type of injury there is usually considerable residual scar tissue and the periosteum in the region of the defect is either entirely lacking or is so badly damaged that it is unable to participate in the nourishment and incorporation of a bone graft or in its replacement by new bone. Much of the original skin has often been lost, and split- or full-thickness grafts have been used in substitution. The remaining mass of soft tissue, which is to a large extent abnormal or foreign to the area, together with the gross defect in bone structure makes replacement most difficult at best and often insurmountable. A short defect of as much as 1 or 2 inches may be bridged by a bone graft which will be nourished from each of the recipient fragments. When the defect is larger, however, the blood supply to the middle portion of the graft, which is surrounded by scar and damaged periosteum, is often inadequate and the graft either fractures or becomes absorbed with consequent operative failure. In addition, there is always the real danger of postoperative infection in these poorly resistant, traumatized tissues, many of which have been previously infected at the time of the original injury.

HISTORY

The apparently effective short-term results with metallic and acrylic prostheses, especially in replacement of the upper end of the femur, have stimulated interest in the use of these materials for the bridging of shaft defects. Dental and plastic surgeons have been using Vitallium replacements successfully for the repair of mandibular, cranial and malar defects for some twenty years. This metal has been shown to be light, inert and well accepted by living tissues. Following experimental investigation by Venable, Stuck and Beach [*25*] and after adequate clinical trial the material has been widely adopted for surgical use.

The first clinical report of shaft defect replacement is that by Delbet and his associates in 1919 [*8*]. These observers used hard rubber rods to replace defects in the shaft of the radius in two patients. The report included only a three-month follow-up period, during which the prostheses were well tolerated. In 1943 Moore and Bohlman [*18*] reported the resection of the upper half of a femur for giant cell tumor, with replacement by a Vitallium prosthesis. Fixation was accomplished by a series of Vitallium bolts. The patient presented a collection of fluid about the prosthesis six weeks after surgery. This necessitated operative drainage with removal of a bony sequestrum. It was noted at the secondary procedure that the periosteum was adherent to the metal and was difficult to strip. The wound proceeded to heal without further difficulty. Union was solid at five months and the patient was walking on the prosthesis nine months after the initial surgery. He died of cardiac failure one and a half years after operation. The autopsy specimen revealed a large involucrum of new bone which had formed around the attachment of the metal to the femoral shaft and had apparently solidly incorporated the two dissimilar structures.

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In 1947 Delitala [9] recorded seven cases of metallic replacement of the shafts of long bones in which defects had been created by operative resection for malignancy of bone. Six of these prostheses were well tolerated but one was removed because of infection. The procedures were relatively recent and there were no long-term end results. In 1950 Loomis [14] reported a procedure similar to that used by Moore and Bohlman with Vitallium replacement of a large defect in the upper third of the femur resulting from an infected gunshot wound which drained for six months. Thirteen months after healing of the wound the prosthesis was inserted and fixed by multiple screws and one band of Vitallium. The postoperative wound healed without incident, and seven years after operation there was solid union with complete incorporation of the prosthesis by a collar of new bone. The functional result was excellent.

Buchman [4] has successfully replaced a massive defect in the shaft of the ulna in a child, utilizing a hollow Vitallium prosthesis which was filled with cancellous bone. There is a six-year follow-up period in this case. MacAusland [16] has reported the successful use of an acrylic prosthesis to replace the lower end of the humerus in four patients. Venable and others [23–25] have used Vitallium prostheses to replace the lower humerus and also to assume the articulating function of the elbow joint. Horwitz [12] has reported the use of adjustable stainless steel prostheses in two resistant fractures of the humerus which had been treated unsuccessfully by bone grafting. The early results in these patients seemed encouraging.

Capurro and Pedemonte [5] have reported the substitution of the entire femur of a cadaver in a patient whose femur had been completely excised for hydatid cysts. While the result is recorded as satisfactory, this type of massive homogenous graft is not likely to be successful in many cases. In 1949 Seddon and Scales [22] reported the use of a polythene substitute for the upper two-thirds of a femoral shaft which was disarticulated for chondromatous dysplasia. The prosthesis was held in position by muscle attachments through a hole in the upper portion and a slot over the distal end. Apparently this furnished sufficient stability and function so that the patient could successfully operate an artificial limb.

The replacement of a massive bone defect by a prosthesis constructed of inert material which cannot conceivably unite with bone seems unphysiologic and mechanically unsound. Obviously it is not to be considered seriously until all efforts at orthodox management have been exhausted and there is the choice between heroic measures and a useless or amputated extremity. It is only under such circumstances that shaft replacement by metal or plastic material would seem to be a realistic approach. However, in support of the method there are certain aspects which seem favorable. Vitallium has been shown to be closely enveloped by bone and held firmly to it even though no actual fusion of these substances can occur. Secord and Breck [21] report their inability to remove a Vitallium plate and screws nine months after insertion, and other surgeons have had similar experience. Bothe and his co-workers [2] state that titanium is fully as well incorporated as Vitallium and stainless steel, perhaps better in that the bone has a tendency to grow into contact with it.

Magilligan [17] has reported the use of a Vitallium Smith-Petersen nail to maintain the length of an extremity in a child who had suffered the loss of a large segment of bone with preservation of its periosteal sleeve in an automobile accident. The intention was to prevent shortening and contracture, with expected subsequent bone replacement by a graft. The Vitallium nail was incorporated in an involucrum of new bone as early as three weeks following injury. There was massive bone formation at two months, so that grafting was not required. Proliferation continued for an additional three months, which is the last available information on record. It is important to emphasize that this patient was a child and that the periosteum was relatively undamaged.

CLINICAL EXPERIENCE

Our clinical experience has been with Vitallium prostheses only and has been limited to the replacement of shaft defects of five long bones. There was one femur, one ulna, one humeral shaft and two which involved the lower third of the humerus including the elbow joint. Four injuries were the result of severe gunshot wounds and the other was due to contact with a buzz saw. All patients except one had had unsuccessful bone grafting procedures which made us consider prosthetic replacement as a final choice. The remaining

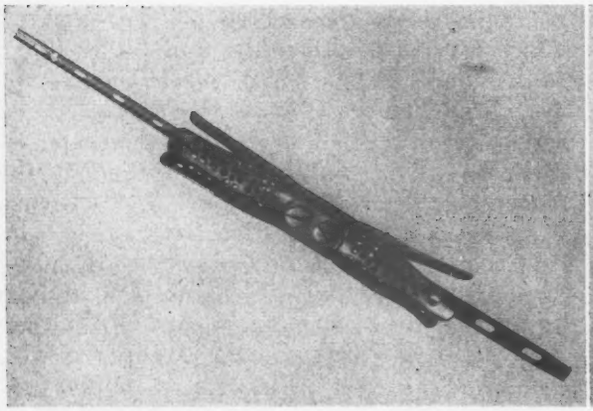


FIG. 1. Prosthesis for shaft of humerus with two parts assembled.

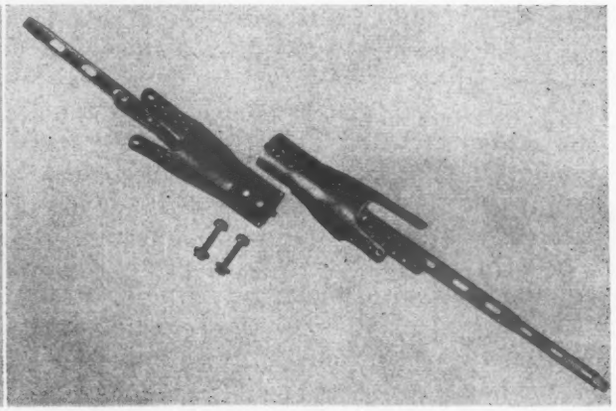


FIG. 2. Prosthesis for shaft of femur with two parts and connecting bolts disassembled.

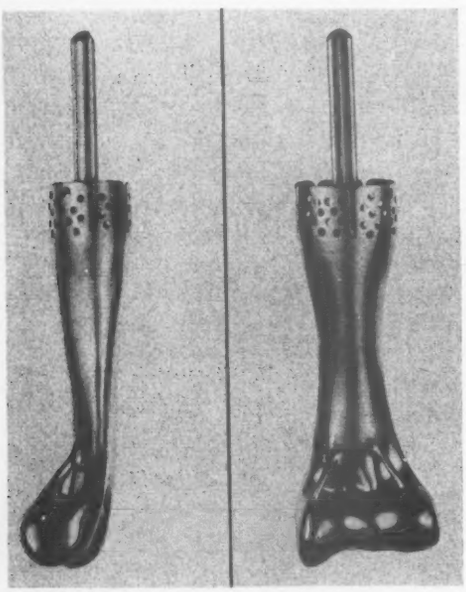


FIG. 3. Prosthesis for lower end of humerus modeled to simulate the flare of the condyles.

patient had a 3 inch ulnar defect which we believed would be difficult to bridge by any type of bone grafting procedure.

The prostheses were constructed individually for the patients from roentgenographic studies and a preliminary surgical inspection of the part to obtain exact bone measurements. In the case of fractures not involving the joint the bone ends were exposed and squared off, bone wax was used to make an impression of the bone ends to be fitted, the diameter of the medullary canals was determined by trial insertion of various sized pins and the length of the defect was measured. Afterward the impressions of the bone ends were filled with plaster to give us exact models for the fitting of the prostheses. The models, operative measurements and roentgenograms were then sent to the manufacturing laboratory for fabrication of the specially tailored prostheses.

All models were made of hollow Vitallium, and in the case of those limited to the shaft an open latticework arrangement was used to permit ingrowth of granulation tissue and provide better fixation to the surrounding soft structures. Two general types were employed but the number is too small for any conclusion concerning the advantages of one over the other. In two patients the prosthesis was in two parts, bolted together in the middle and with a medullary nail at each end. (Figs. 1 and 2.) There was a full cuff at each end to fit over the respective bone fragment. A third prosthesis was fitted at one end with a full cuff and medullary nail and at the other end with a half cuff held in position by two transfixing bolts.

The prostheses which included the elbow joint also were inserted following preliminary surgical exploration to obtain an impression of the squared off proximal fragment, measure the diameter of its medullary canal, obtain the proper length of the prosthesis to fill the defect and estimate the transverse diameter of the prosthesis at the level of the condyles. (Fig. 3.)

OPERATIVE RESULTS

The prostheses were inserted without difficulty and there were no immediate postoperative complications. All extremities except the one with the ulnar defect presented the surgical conditions to be expected in lesions of this kind, namely, full-thickness skin grafts, skin

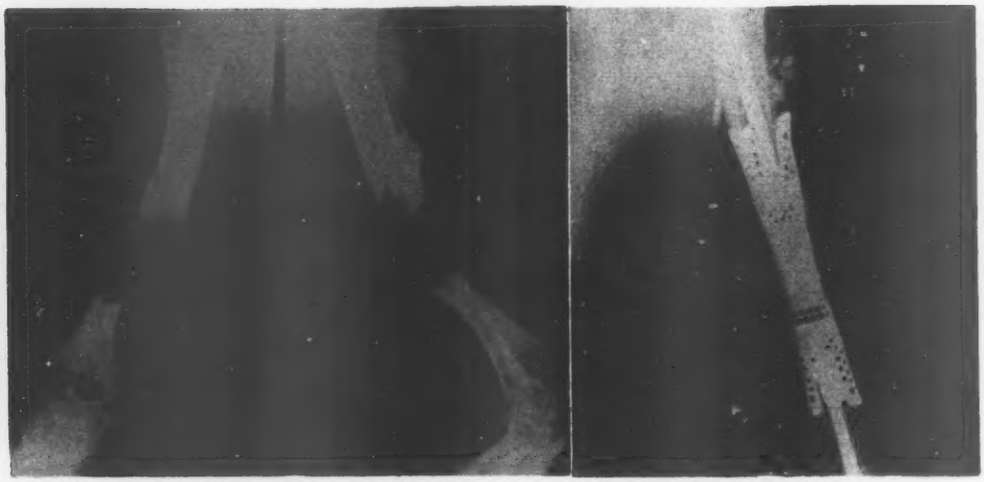
4A 4B

FIG. 4. A, roentgenogram of massive defect in lower third of humerus. B, roentgenogram following insertion of single piece Vitallium prosthesis. There is evidence of beginning incorporation of the upper end of the prosthesis in a collar of callus but the condylar portion is protruding through the wound.

scars, extensive scarring of other soft tissues and destruction of periosteum.

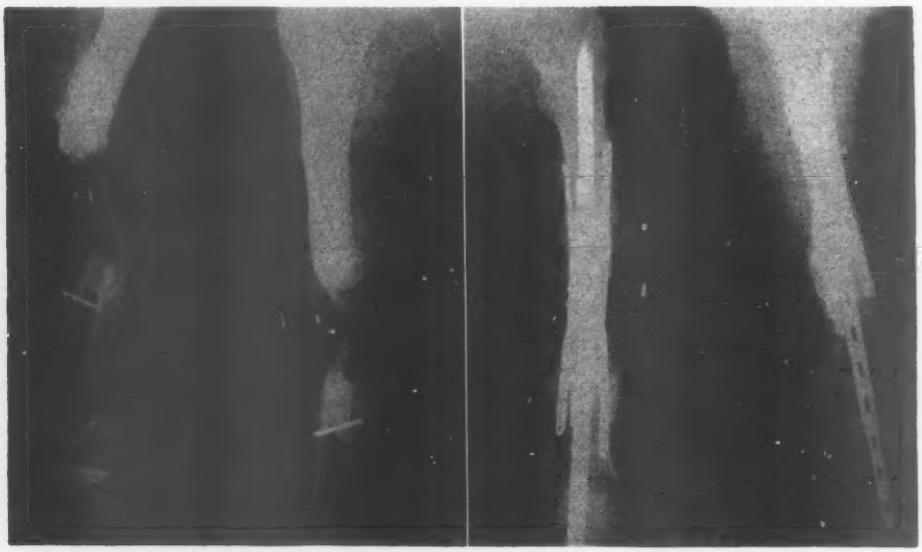
There was difficulty with healing of the skin in four patients. No definite infection was present primarily but the incisions gradually separated as a result of what appeared to be a collection of blood and serous material around the prostheses together with inadequate nutrition of the skin. Efforts at resuture were made, to no avail. The prostheses gradually became more apparent in the wounds and removal was required in all four. In all patients there was some beginning incorporation of the cuffs of the prostheses by surrounding tissue but none of the four prostheses remained in place more than sixteen weeks, so that complete bony incorporation could not be expected. There appeared to be a membranous lining of the cavity which surrounded the body of the prosthesis in all cases. Apparently incorporation was taking place at the points of attachment to the bone but not along the prosthetic shaft. In the latter area the adjacent synovial type of tissue reaction continued to surround the prosthesis with fluid despite efforts at drainage. Secondary infection occurred in all four cases. In addition we noticed that in the two cases which included the elbow joint there was a tendency for the humeral fragment and the prosthesis to become externally rotated in relation to the forearm bones. This eventually resulted in protrusion of the condylar portion of the prosthesis through the skin wound. This occurred in spite of immobilization of the arm in a plaster spica. None of the other unfortunate results could be attributed to inadequate postoperative immobilization since this was accomplished by plaster fixation or suspension of the leg in all cases. (Figs. 4, 5 and 6.)

One prosthesis has remained in place after eighteen months. This is an ulnar shaft replacement, and roentgenograms reveal that there is partial incorporation of the distal attachment of the prosthesis but only the slightest evidence of a surrounding bony collar proximally. (Fig. 7.) This patient presents clinical union at the distal attachment but there is still some discomfort on manipulation of the proximal attachment. The patient uses his arm without significant pain and we believe that this prosthesis will serve a useful purpose. It is probably of the greatest importance that this is the one patient who had minimal scarring and periosteal damage prior to reconstruction and whose injury was due to a buzz saw and not to a gunshot wound. It is also of lesser significance that he is the only patient in whom we used



5A 5B

FIG. 5. A, roentgenogram of massive defect in the shaft of the humerus. B, roentgenogram following insertion of two-piece Vitallium prosthesis which is bolted at the point of junction. At one month following insertion there is considerable encircling callus at the proximal attachment but very little at the distal end.



6A 6B

FIG. 6. A, roentgenogram of massive defect in the shaft of the femur. B, roentgenogram following insertion of two-piece Vitallium prosthesis. The lower pin penetrates the ankylosed knee joint for better fixation. At six weeks there is considerable encircling callus at the distal attachment.

associated cancellous bone grafts about the proximal and distal attachments of the prosthesis. However, the absorption of a great deal of this bone graft material was noted on the roentgenogram within the first few months after its insertion, so that this was a very questionable factor in the relative success of the procedure.

EXPERIMENTAL STUDIES

Fifteen mature mongrel dogs were employed. In order to obtain suitable prostheses a sample of an average femur (weight bearing) and an average ulna (non–weight bearing) was obtained. A 1 inch segment was removed from the upper third of the ulna and a 1½ inch

7A 7B 7C

FIG. 7. A, roentgenograms of massive defect in shaft of ulna. B, roentgenogram two weeks after insertion of one-piece Vitallium prosthesis. Cancellous chips from the iliac crest have been placed around the proximal and distal points of attachment. C, roentgenogram four months after surgery showing well marked encircling collar of callus and bone at distal attachment, with practically none at proximal attachment. The bone chips inserted at operation have been absorbed.

segment was removed from the middle of the femoral shaft. From these specimens the manufacturer made up small Vitallium prostheses engineered to fill the gaps in the bones and conform in general to the shape of the cut bone ends. The prostheses were made as light as possible commensurate with strength and all were fenestrated to permit ingrowth of surrounding tissue.

There were two general types. In one the prosthesis was in a single piece with a full encircling cuff at one end, accompanied usually with an intramedullary pin. At the other end there was a half cuff fixed by one or two transfixing Vitallium bolts. The other type was a two-piece model with full cuffs and intramedullary pins on both ends. The two halves were applied individually and then bolted together at the middle where they were precisely fitted. The former type seemed best suited for the smaller ulna, whereas the latter variety seemed more appropriate for the femur. (Fig. 8.)

Defects were created and the prostheses inserted in ten ulnas and five femurs. The dogs were given routine diets and all had penicillin postoperatively. The wounds all healed *per primam* and the animals tolerated the procedure well. Without exception they were ambulatory a few days after surgery and there was no collapse of the prosthetic attachment in any case.

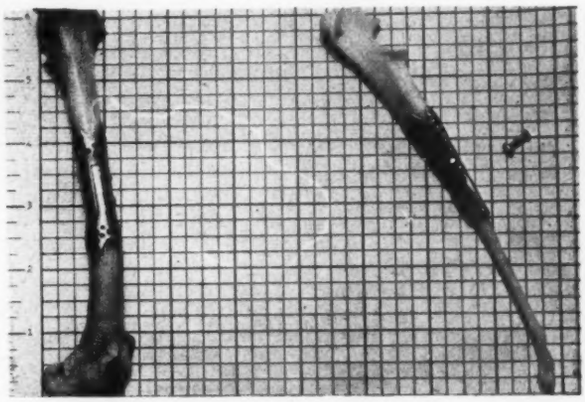


FIG. 8. Vitallium prostheses used in animal experimentation. The two-piece prosthesis on the left replaces a 1.5 inch defect in a dog's femur. The one-piece prosthesis on the right has an intramedullary nail attached to the proximal portion and a half cuff and retaining bolt at the distal portion. It replaces a 1 inch defect in a dog's ulna.

Roentgenologic Findings. Films were taken shortly after surgery and at monthly intervals. At the end of one month there was evidence of

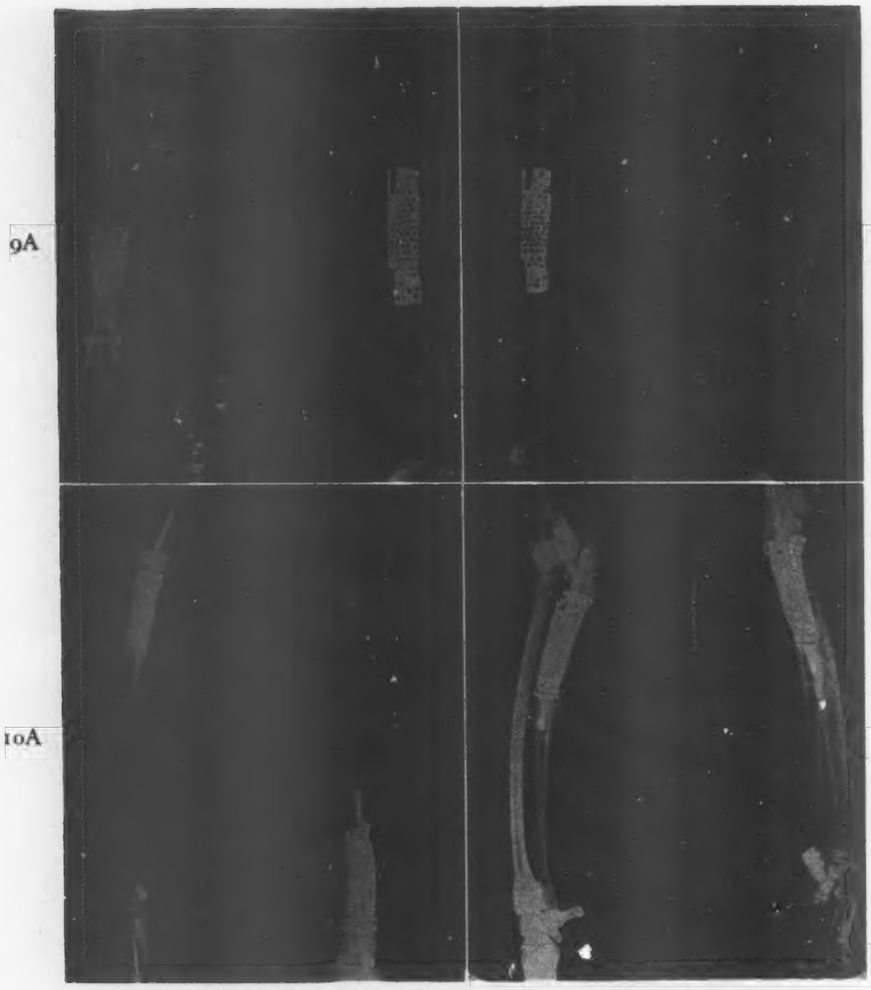


FIG. 9. A, immediate postoperative roentgenograms of defect in dog's ulna replaced by single piece Vitallium prosthesis. B, roentgenograms one month later showing beginning encirclement by callus at the proximal attachment and continuing along the shaft of the prosthesis.

FIG. 10. A, Immediate postoperative roentgenograms of defect in dog's ulna which has been replaced by a two-piece Vitallium prosthesis. B, roentgenogram three months later showing incorporation of the prosthesis in bony callus.

a collar of bony callus at the junction between the prosthesis and the bone. (Fig. 9.) This progressed in some cases so that there was an encircling layer of bony callus throughout the entire length of the metallic prosthesis. (Fig. 10.) It will be noted, however, that there was usually an area of rarefaction between prosthesis and encircling callus, designating an absence of close contact between the two dissimilar structures. The amount of encircling material varied with the different animals. In some it reached its maximum at two months and remained constant. In others it seemed to progress gradually for an additional period of several months.

Gross Pathological Changes. The animals were sacrificed at intervals and the operative sites were studied for evidence of incorporation of metal in bony callus, especially at the areas of the cuffs of the prostheses which encircled the bone ends. In all cases the adherence of callus to metal was so firm that considerable force was required to separate the two structures. This surprising fixation occurred as early as one month following insertion of the prosthesis but seemed stronger in the animals which were sacrificed at periods up to four months. The gross appearance was that of a calcified fibrous callus material which resembled the substance normally produced at fractured

FIG. 11. Gross specimen of single piece prosthesis and attached sections of ulna removed from dog two months after operation. The bony callus surrounded the entire prosthesis and was stripped with great difficulty.

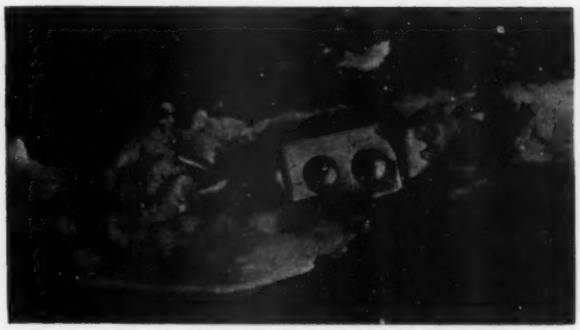


FIG. 12. Gross specimen of two-piece prosthesis and attached sections of femur removed from dog two months after operation. The bony callus was firmly attached along most of the surface of the prosthesis.

bone ends in the healing process. (Figs. 11 and 12.)

Microscopic Changes. Sections were taken from the calcified callus which surrounded the cuffs of the prostheses. This tissue was decalcified in the usual way and stained with hematoxylin and eosin. The sections were reviewed by Major Joseph H. Masters, who reported as follows: "Microscopic sections include areas of a granulation tissue, fibrous scar, young cellular fibrous tissue and bony callus with areas of osteoid, chondroid and cartilage; callus proliferation is active as manifested by the numerous palisades of osteoblasts about the periphery of the osseous spicules. Some sections contain an amphophilic granular tissue debris surrounded by granulation tissue containing a mononuclear cell infiltrate, a few osteoclasts and many hemosiderin filled macrophages. At the margins of the bone there is intramembranous bone formation with a proliferation of connective tissue cells and alignment of osteoblasts about the periphery of newly formed osteoid and osseous spicules. There are small areas of chondroid and columns of cartilage cells in which histologic features of endochondral ossification is seen."

COMMENTS

The clinical results obtained in our patients with Vitallium shaft prostheses are not encouraging. On the other hand, the successful experimental results offer a ray of hope that the procedure may, after further investigation and development, be the basis for an improved method of treatment of these difficult problems.

It is unfortunate that in the situations in which they are most needed these devices offer the least hope for success. In our animals there was normal tissue at the operative site, an intact periosteal sleeve and no scarring. In our one successful prosthetic insertion in a patient the same conditions existed. Such tissues also respond well to bone grafting, provided the length of the defect is not too great. In severely damaged tissues, such as the residuals of gunshot wounds, where the need for artificial replacement is the greatest, the chances for success by our presently available methods would seem to be rather poor.

Vaughan-Jackson [*26*] suggests that the future development of a protein plastic substance may bridge the gap between living and inert substances and so induce permanent adhesion between an inert prosthesis and living bone. From the practical point of view, actual union of bone and prosthesis may not be necessary provided there is a solid mass of bone originating from the recipient fragments to incorporate the inert material rigidly. This has apparently happened in the experience of others; and if the mass of incorporating bone is strong enough to withstand the pressure, tension and torsional stresses of function, the result may be satisfactory regardless of whether or not the procedure is physiologically sound. In these successful cases, however, an adequate amount of surrounding healthy bone and soft tissue will be essential to furnish the stimulus for the incorporating material. Where there is excessive scar tissue and loss of periosteum it is unlikely that incorporation will occur, and the mechanical attachment of prosthesis to bone by surgical means will be insufficient to withstand the strain of functional activity. This is especially true in weight bearing extremities.

It is clear that additional investigation of this method of bridging shaft defects is required. Other concepts, materials and technics may bring future success. Our good results in animals and in the one patient with relatively normal soft tissue covering may stimulate further study of the problem.

SUMMARY

1. A clinical and experimental study has been made of the bridging of defects in the shafts of long bones by Vitallium prostheses.

2. Only one patient of five retained his prosthesis. In the remaining four, failure was apparently due to the severe residuals of local trauma and inadequate soft tissue coverage.

3. In animals when there was no previous local trauma the prostheses were adequately covered by soft tissue, were well tolerated and all were retained. Postoperative films showed prompt encirclement of the prostheses by calcified callus.

4. Further investigation of the bridging of bone defects by foreign materials seems justified.

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The Effect of Compression on the Rate of Fracture Healing Using a Special Plate*

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THE effect of a compressing force at the site of a fracture has been of interest for many years. This interest stems from Wolff's law [1] which deals with the effect of stresses and strains on the architecture of bone. If stresses and strains stimulate a bone to become heavier and stronger, can a similar osteogenic effect be obtained by stress in the form of compression at the site of fracture?

The effects of compression on a fracture may be outlined as follows:

I. Advantages
  A. Direct effect
    1. Compression effect *per se*
  B. Indirect effect
    1. Close approximation
      a. Mere process of decreasing the fracture gap
      b. Stimulation of osteogenesis by induction
    2. Better immobilization
II. Disadvantages
  A. Pressure necrosis

Before we began our study we believed that compression could have the direct effect of stimulating osteogenesis at a fracture site. This attitude was based on hope, instead of facts, because we had a device that would seemingly harness this compressing or osteogenetic-stimulating factor and could be applied as practically as an ordinary bone plate. The maxim which should have made us predict differently was that factors that cause healthy organs or tissue to hypertrophy are usually not advantageous to a damaged organ. For example, a muscle and tendon will hypertrophy with exercise, but after laceration and repair, rest, not exercise, is in order. A fractured bone likewise should be put at complete rest to encourage repair, and should not be subjected to stresses and strains of compression with the idea of stimulating osteogenesis.

The indirect effects of compression are generally considered advantageous within reasonable limits. The simplest way of explaining the indirect advantages of compression is to point out that compression reduces the fracture gap to a minimum and therefore less time is required to span the gap with callus. Furthermore, Urist and McLean [2] pointed out that contact is an important prerequisite to the induction process of stimulating osteogenesis. This tends to support the argument that close approximation of fragments actually stimulates osteogenesis, and would explain why a formidable gap will lead to delayed union or non-union.

Compression helps immobilize the fragments. It is reasonable to argue that good immobilization favors early repair of a fracture. Frequently, a large amount of external callus is laid down when motion is known to be present. This should not be misinterpreted to mean that motion is stimulating osteogenesis. This callus is being deposited parallel to the fracture line, and not across it, as it should be. It is well established that the fracture hematoma must be organized and invaded by capillaries before bone formation can follow. Movement of the fragments could not possibly be an advantage to capillary growth across the fracture line.

Combining the factors of close approximation and rigid immobilization may allow a fracture to heal by first intention rather than secondary

* Abridgment of thesis submitted by Dr. Bagby to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Orthopedic Surgery.

intention. It is possible to compare the healing process of bone and soft tissue on the basis of first and secondary intention which was suggested by Lane [3] in 1914. Since the time required to unite a large bone is longer than that of a small one, generally speaking, it must follow that the usual process of bone healing is one of secondary intention. This is consistent with the fact that long and short wounds in soft tissue heal in the same time, when they heal by primary intention. Our idea of bone uniting by primary intention is that the callus will proceed directly across the fracture line at the same rate at all points and with a minimum of cartilage and external callus formation. According to this, only fractures under ideal circumstances unite by primary intention, but it is a situation worth striving for.

The one possible disadvantage of pressure is necrosis of bone due to excessive pressure. Freidenberg and French [4] measured the compression forces applied in an effort to determine what range of pressure was advantageous and at what point pressure necrosis developed. It was difficult to draw conclusions on this score with accuracy because of other factors. The bone in their experiment had to be osteotomized in two places, thus reducing the blood supply. Furthermore, no particular attempt was made to control or determine motion of the fragments. A fragment may necrose when pressure is exerted on it if motion occurs, but may not necrose under otherwise similar circumstances if no motion occurs. Again, the necrosis may be due to interference with blood supply to the site of fracture.

THE LITERATURE

A review of the literature revealed that Key [5] was the first to apply compression with the idea of stimulating osteogenesis. He used it postoperatively to produce arthrodesis in the knee joint. Pins were inserted above and below the knee and were drawn together with turnbuckles. Although the method was effective, Key did not consider in later conclusions [6,7] that osteogenesis was stimulated by compression, but attributed the advantage to the close approximation created by the compression. Charnley [8–10], on the other hand, used a method similar to Key's on various joints and stated that osteogenesis actually was stimulated by compression of the fragments.

Muscles spanning the fracture compress the fragments together. Intramedullary fixation as well as slotted plates are designed to allow this physiologic compression to exist. Eggers [11–13] pointed out the advantage of having bony contact and compression of the fragments by muscle tone, but his plate has been criticized because fibrous tissue invaded the slots and prevented sliding of the fragments on the plate. Eggers also stated that osteogenesis is actually stimulated by compression of bony fragments together.

Reynolds and Key [14,15] compared the results of fixing osteotomized femurs of dogs with slotted plates (Eggers), standard bone plates (Lane) and intramedullary pins. They concluded that the type of plate used did not make much difference. The intramedullary pins which they used did not fit well and, therefore, the results were obscure.

Key, Eggers, Charnley, and Freidenberg and French agreed that compressing bone fragments together has advantages as long as the degree of compression is not excessive. They disagreed on the mechanism involved.

We found three coaptating plates described in the literature. Danis' [16] plate featured a coaptating screw at the end of the plate. He also described special instruments for applying his plates, one on each side of the bone, through one incision. Venable [17] described a similar plate, but the impacting screw at the end advanced at an angle of 45 degrees to the bone, rather than parallel to it, as did Danis' screw. Boreau and Hermann [18] used a bipartite plate, the parts to which are connected by a cylindrical bolt which will pull the fragments together. All these seemed to be practical, although special instruments were needed and no dynamic factor was incorporated into them. Furthermore, neither clinical nor experimental work has been presented to show an advantage in their use.

MATERIAL AND METHODS

In order to study the effect of compression on healing of fractures we sought first to perfect a bone plate that could be applied internally as practically as plates already in common use, and that would compress the bone fragments also.

We began with a modification of a Collison bone plate that was rather involved and required special screws. During the experimenta-

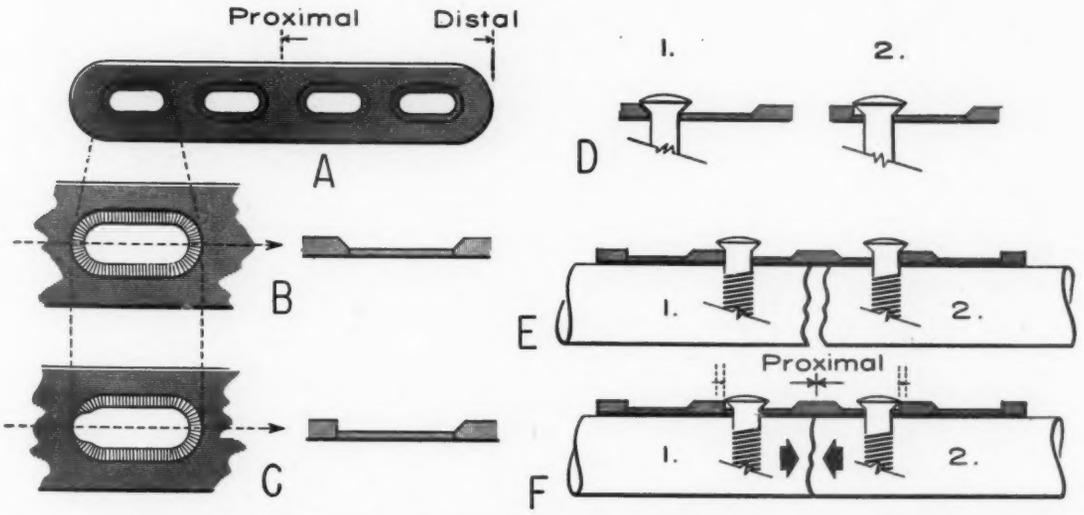

FIG. 1. Use of a modified Collison bone plate to apply compressing force. A, unaltered Collison plate .B, views of Collison plate in longitudinal section. C, views of modified Collison plate. The distal slanted end of the slot has been made vertical. D, this shows (*1*) the relationship of a screw in the slot of an unmodified plate and (2) the relationship in a modified plate. E, screws in position in a modified plate. At least two screws must be brought to this position before completely turning them down to create the impacting force. F, screws have been turned down and the fragments have become more closely approximated.

tion three different screws were used. Finally, we made a much simpler alteration in the plate which permitted use of the regular Collison screws. This modification and the technic for applying it was described elsewhere [*19*]. Since all the plates made use of the same principle for creating compression, we will only describe the final one.

The Plate. In a regular Collison plate the slots have slanting sides. The modification consisted merely of converting the side of each slot distal from the center of the plate to a vertical one. The screws were placed adjacent to these converted sides after the fragments had been reduced and the plate was being held in place with a Lowman clamp. At least one, and preferably two, screws were started on each side of the fracture site before any of them were turned down tightly. As each screw was tightened, the slanted undersurface of the head of the screw hit the edge of the plate and forced the fragment to slide so that the plate could accommodate the head of the screw. (Fig. 1.) This is a static factor and only serves to bring the fragments close together. A dynamic factor also is incorporated in this system. (Fig. 2.) The dynamic factor was not anticipated but was recognized in applying the plate to the concave surface of the dog's femur. On perfectly flat bone surfaces a slightly convex (2 to 3 degree) plate should be used. The important point in this connection is to get the two cortices together on the side opposite the plate before the two next to the plate. When this principle was followed, the adaptation of the fragments to each other was better.

We could not determine the compression force created at operation, but at necropsy the fragments of the femur of the dog could be made to slide against 85 pounds of total resistance.

The General Plan. Using the general plan of Key and Reynolds to compare fixation, we applied a Collison plate to femurs of dogs in the control series and a compression plate to the femurs of other dogs or the other femur of the same dog. Thiopental sodium anesthesia and the usual aseptic technic were used for surgical procedures.

Animals Studied. Group 1 consisted of twenty-three large, adult mongrel dogs weighing 12 to 22.7 kg. Since a cast seemed ill-advised, osteotomy was performed on the left femur only of each dog, thus allowing him one good hindleg to use and for protection of the fractured one. This necessitated having a control dog for each experimental one, and osteotomy was performed on the left femur of each dog in the control group also before the Collison plate was applied. On the controls the screws

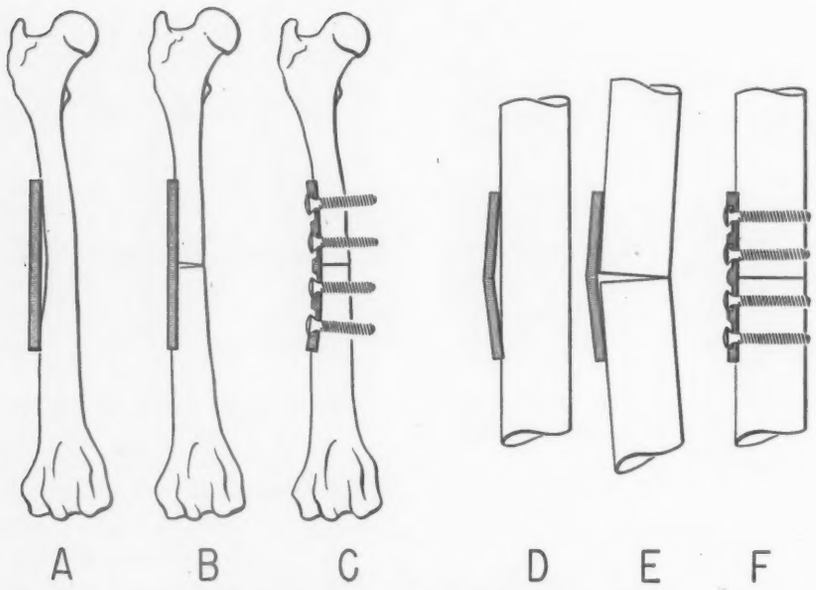

FIG. 2. Use of a modified Collison bone plate to incorporate a dynamic impacting force. On a slightly curved surface a straight plate creates the effect shown in (A, B, and C). A, relationship of plate to bone. B, relationship of fragments to plate as held by a Lowman clamp. The gap in the fracture becomes wedge-shaped. C, the impacting force has been applied, thus closing the gap and springing the plate. (D, E and F). A similar effect can be accomplished when the surface of the bone is flat.

were applied just loose enough to allow sliding of the fragments.

Experience with group 1 helped us iron out the difficulties of applying the new plate. We found that the dogs were too large for the size of the plates (FF) we used and, therefore, excessive motion resulted in plates and screws breaking in some cases. We realized that better control would be available if we used one femur for control and the other in the same dog for experimentation, since the dogs did not seem to favor the fractured limb appreciably, as we had expected.

Accordingly, a second group of dogs (group 2) was studied. This consisted of ten adult mongrel dogs varying in weight from 8.5 to 13.9 kg. Osteotomy was performed with Gigli's saw and a regular Collison plate was applied to the right femur. As invariably occurs, Gigli's saw left a small nubbin of bone, and it was necessary to bite this off with a ronguer in order to obtain uniform cuts. The wound was closed after application of the Collison plate, the dog was turned over and the compression plate was applied to the left femur after a similar cut was made through it. Before each dog awakened from the anesthesia, he was given 300,000 units of penicillin and roentgenograms were made of both femurs. Other details about the application of the plates will be mentioned with the results.

The dogs were re-examined at frequent intervals for signs of motion of the fragments, and roentgenograms were obtained. As soon as one femur on either side appeared to be united, the dog was killed. At necropsy, the femurs were removed, roentgenograms were made with the plate in place, and the length of each femur was determined with calipers. The plates were then removed and in doing so we noticed whether the experimental plates straightened up, since this would indicate to some extent whether the dynamic factor was still in force. We also determined whether any motion was present in the femur. A section of bone including the fracture site and a screw hole on both sides of it was then removed. After decalcification, sections for microscopic section were made through the fracture site and screw holes.

Criteria for Determining Union. The following criteria were used for determining bony union. (1) If motion existed after the plate was removed, bony union was considered to be absent, but if no motion existed, either carti-

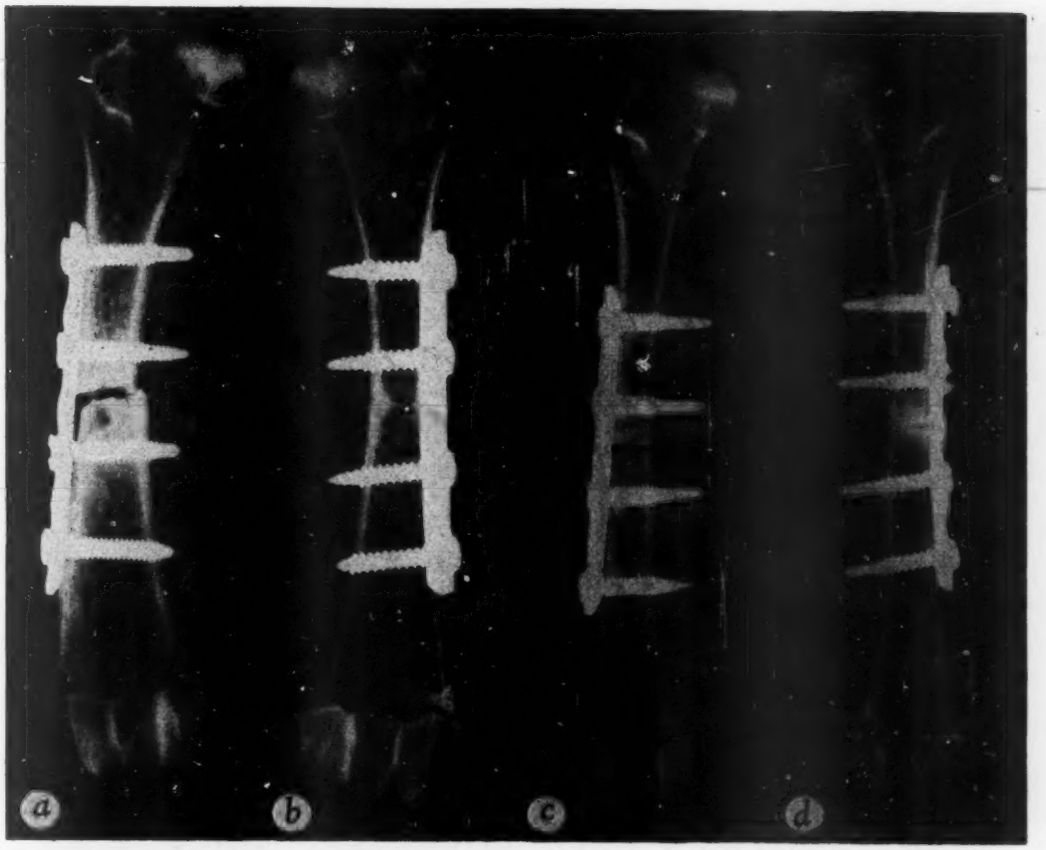

FIG. 3. The femur of dog 2 after fifty-one days of healing (*a* and *b*) and the femur of dog 3 forty-two days after osteotomy (*c* and *d*). (*a*) The control plate was applied just loosely enough to allow sliding of the fragments on the plate. Motion was present, compression was present only by virtue of the muscle pull and the fracture, and the gap was not reduced to a minimum. Bone-to-bone contact was effected at operation. There was no bony union. See Figure 4*a* for section. (*b*) Compressing plate employed. No perceptible motion and the gap was reduced correspondingly to a minimum. Bony union. See Figure 4*b* for cross section. (*c*) The control plate was applied with the screws turned tightly to create rigid fixation without compression. Bone-to-bone contact was present but the fracture gap was not reduced to a minimum since no compression was present. There was no bony union. See Figure 4*c* for section. (*d*) Compressing plate employed. The fracture was fixed rigidly, compression was present and the gap was correspondingly reduced to a minimum. Bony union occurred. See Figure 4*d* for section.

laginous or bony union could be present. (2) When trabeculae could be seen to cross the fracture line on gross examination, bony union was considered present. (3) When one or more trabeculae of bone could be followed microscopically across the fracture line and were found to be uniting to both fragments, bony union was considered present. The microscopic appearance was used as the final resort in determining whether or not bony union existed.

Obliteration of the fracture line in the roentgenogram gave substantial evidence of bony union, but the roentgenograms are of limited value in determining when the first few trabeculae have formed across the fracture line. Of course, the roentgenograms were helpful in determining when to kill the dogs.

RESULTS

The results of group 1 were inconclusive as far as the primary problem was concerned. The data are recorded in Table 1 for the sake of completeness. Study of this group, however, gave us some indication of just how slowly a dog's femur may heal. This is worth mentioning since some critics have the false impression that femurs of a dog will unite rapidly under any circumstances. Some shortening occurred in this group. It was especially prevalent in the control series in which the screws were not as

tightly turned as in the other group. It was significant only when non-union was present at the end of the study.

In group 2 both femurs were utilized in each dog. A low grade infection developed on the control side of dog 1 and the compressing plate loosened in the same dog, due to a technical error in applying it. When this dog was killed, both sides were ununited but the fracture on the side of the infection was more stable and closer to union. In dogs 1 and 2 the control plate was applied with screws turned tightly and then turned back enough to allow sliding of the fragments. The fragments were made to slide back together manually before the wound was closed. Therefore, it was considered that rigidity, compression and a minimal gap were present on the side of the compressing plate, but all three were absent on the control side. In dog 2 progress was much better on the side of the compressing plate. (Figs. 3*a* and *b* and 4*a* and *b*). Thus, when plates were applied to dog 3 the screws were turned tightly on the control side and left that way, since it seemed likely that the motion allowed by the control plate might have been responsible for the difference in uniting time in dog 2. Therefore, in dog 3 it may be considered that rigidity was present on both sides but compression and a minimal gap were present only on the side of the compressing plate. Again the fracture treated by the compressing plate united but the other side did not (Figs. 3*c* and *d* and 4*c* and *d*). In an effort to make the compression factor the only variable, we tried to make immobilization and close approximation equal on both sides and we thought we had succeeded. However, in dogs 4 through 10, we gave each control plate a slight bend so that it would conform better to the slightly concave surface of the dog's femur. As a result the two femurs of all seven dogs united or failed to unite in the same time. (Figs. 5 and 6.) This is the basis for our contention, that under laboratory conditions where immobilization and close approximation of the fragments can be maintained, compression has no effect on the rate of healing.

Results in group 2 are summarized in Tables 1 and 11.

Since the earliest union in the series was obtained in dog 10 (Figs. 5*c* and *d* and 6*c* and *d*), it must have had the most favorable circum-

TABLE 1
SUMMARY OF RESULTS IN GROUP 1 AND GROUP 2

Results	Group 1	Group 2
Dogs on which study was completed	19*	10†
Osteotomy		
Left femur only	19	.....
Both femurs	.....	20
United femurs	10	12
Control	5	5
Experimental	5	7
Days for union (avg.)‡	134.8	44.4
Range‡	77–209	20–66
Shortening of femur	.....	0
Average for union (cm.)	0.08§	.....
Average for ununited (cm.)	0.15§	.....

* One femur in each dog fractured.
† Both femurs in each dog fractured.
‡ Days to end of study but determined only from those that were united.
§ Compared to unfractured control; 0.1 cm. deducted to allow for width of cut made by Gigli's saw and removal of nubbin.

TABLE 11
DETAILED RESULTS ON UNION IN GROUP 2

Dog No.	Weight (kg.)	Healing Period (days)	Union, Side of		Remarks
			Control Plate	Compressing Plate	
1	10.7	79	No	No	Control: mild infection; experimental plate loosened due to technical error
2	11.0	51	No	Yes	Control plate applied to allow sliding of fragments
3	10.2	42	No	Yes	Control plate applied with screws turned tightly
4	13.9	36	No	No	Control plate applied with screws tightened and bent slightly to conform to concavity of femur
5	10.0	44	Yes	Yes	
6	11.5	66	No	No	
7	11.2	66	Yes	Yes	
8	13.6	33	Yes	Yes	
9	13.0	57	Yes	Yes	
10	8.5	20	Yes	Yes	

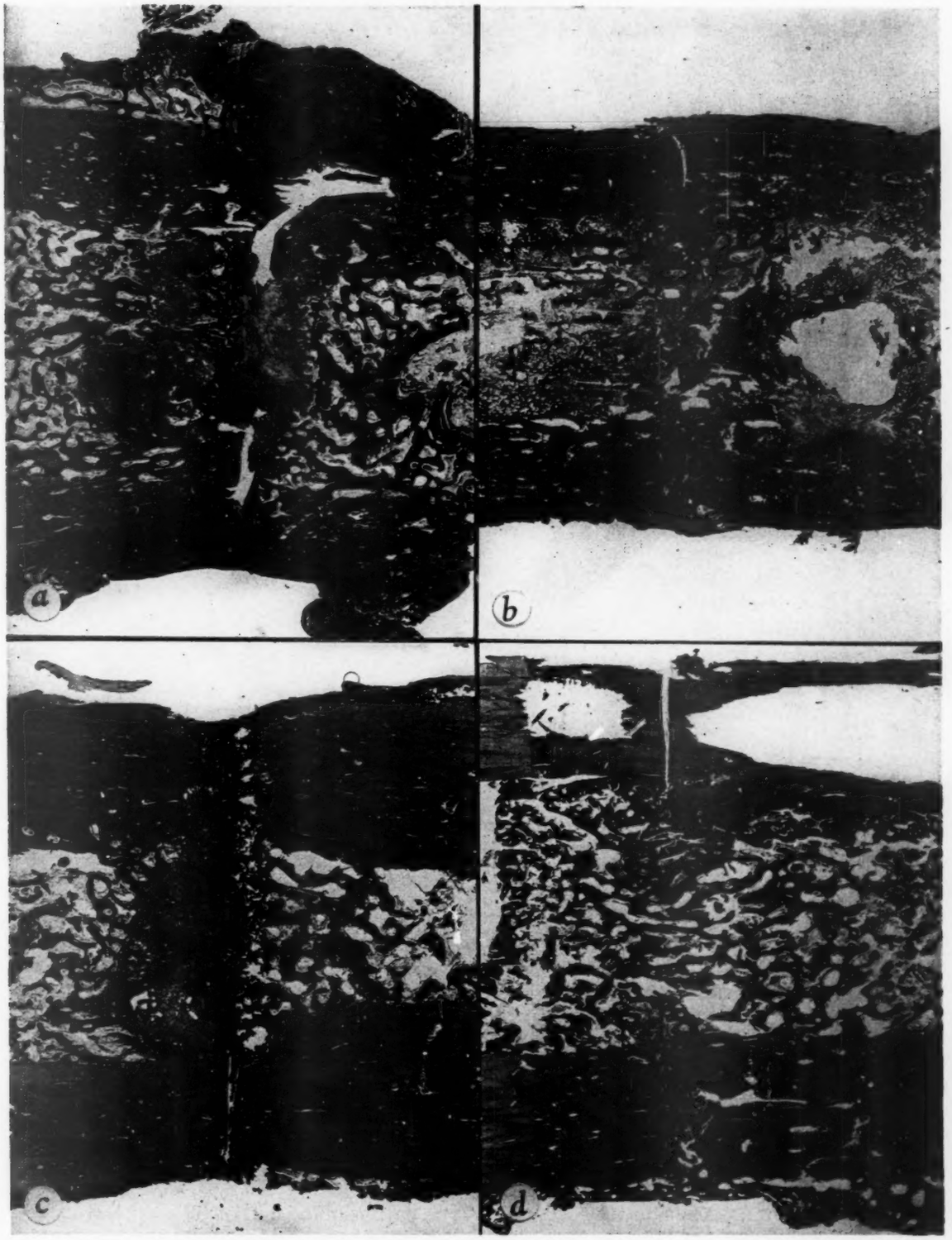

FIG. 4. Sections through fracture sites shown in Figure 3, in dog 2 after fifty-one days of healing (*a* and *b*, hematoxylin and eosin × 6½), and in dog 2 forty-two days after osteotomy (*c* and *d*, hematoxylin and eosin × 9). (*a*) Femur shown in Figure 3*a*; control plate. No bony union. (*b*) Femur shown in Figure 3*b*; compression plate. Bony union. (*c*) Femur shown in Figure 3*c*; control plate. No bony union. (*d*) Femur shown in Figure 3*d*; compression plate. Bony union. For details of application of plates see Figure 3 and text.

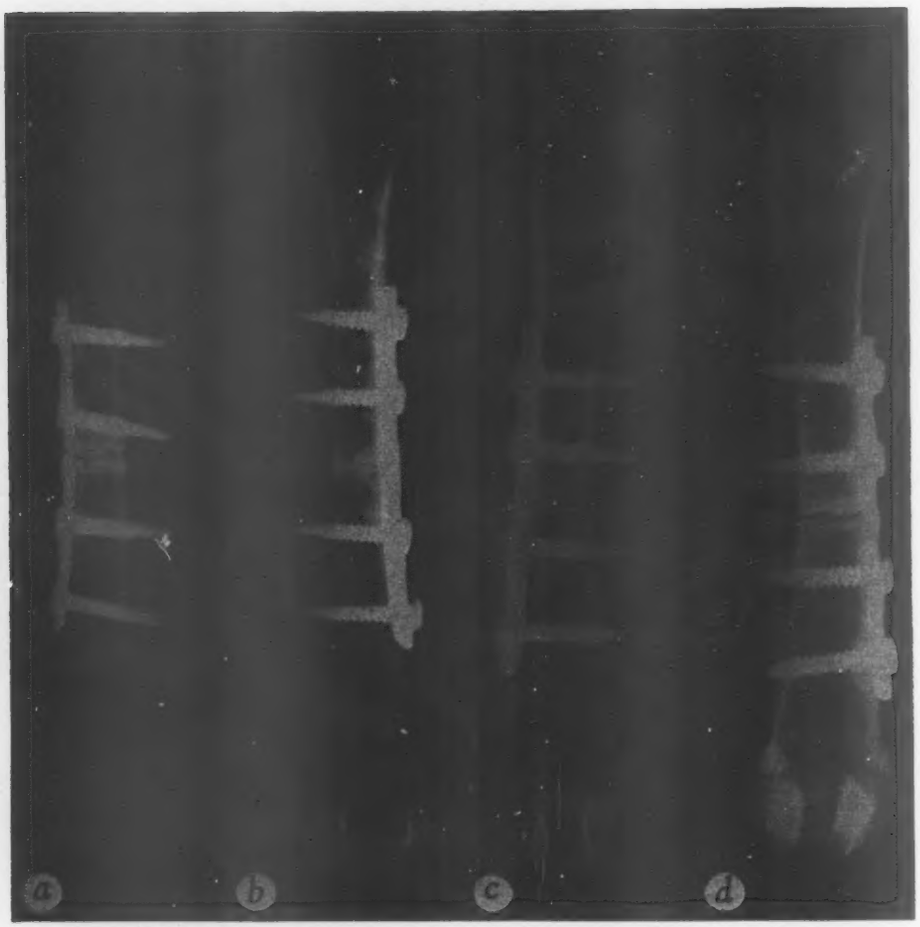

FIG. 5. The femur of dog 8 thirty-three days after osteotomy (*a* and *b*) and the femur of dog 10 twenty days after osteotomy (*c* and *d*). Bony union was present in both femurs. (*a*) (Control.) The fragments were held rigidly and the fracture gap was reduced to a minimum by utilizing a slightly bent plate to conform to the curve of the femur. No compression was present. There was bony union. See Figure 6*a* for section. (*b*) Compressing plate was employed. Fixation was rigid; compression and a correspondingly minimal fracture gap were present. There was bony union. This illustrates that compression has no advantages when rigid fixation is maintained and the fracture gap is minimal. See Figure 6*b* for section. (*c*) (Control.) The fracture was rigidly fixed and the fracture gap was reduced to a minimum without compression. See Figure 6*c* for section. (*d*) Compressing plate employed. Rigid fixation with compression and a correspondingly minimal gap. See Figure 6*d* for section.

stances present. Therefore, it should be noted that this was the smallest dog used, and since all the plates used were of similar length it is rational to consider that this one came closest to having perfect immobilization. Therefore, this dog points up the importance of rigid fixation and close approximation as the key to early union and that compression *per se* is not a factor.

One observation with regard to the healing of the fracture should be mentioned. The fractures that united early in our study showed little external callus, and the fractures with much external callus usually united more slowly.

COMMENTS

The results of our study furnish strong evidence that compression of bony fragments does not hasten union except by virtue of its bringing the fragments closer together and adding to immobilization. However, the evidence points up the importance of rigid immobilization and precise anatomic reduction of the fragments. We realize that a clinical fracture is not as easy to handle as an osteotomy, but

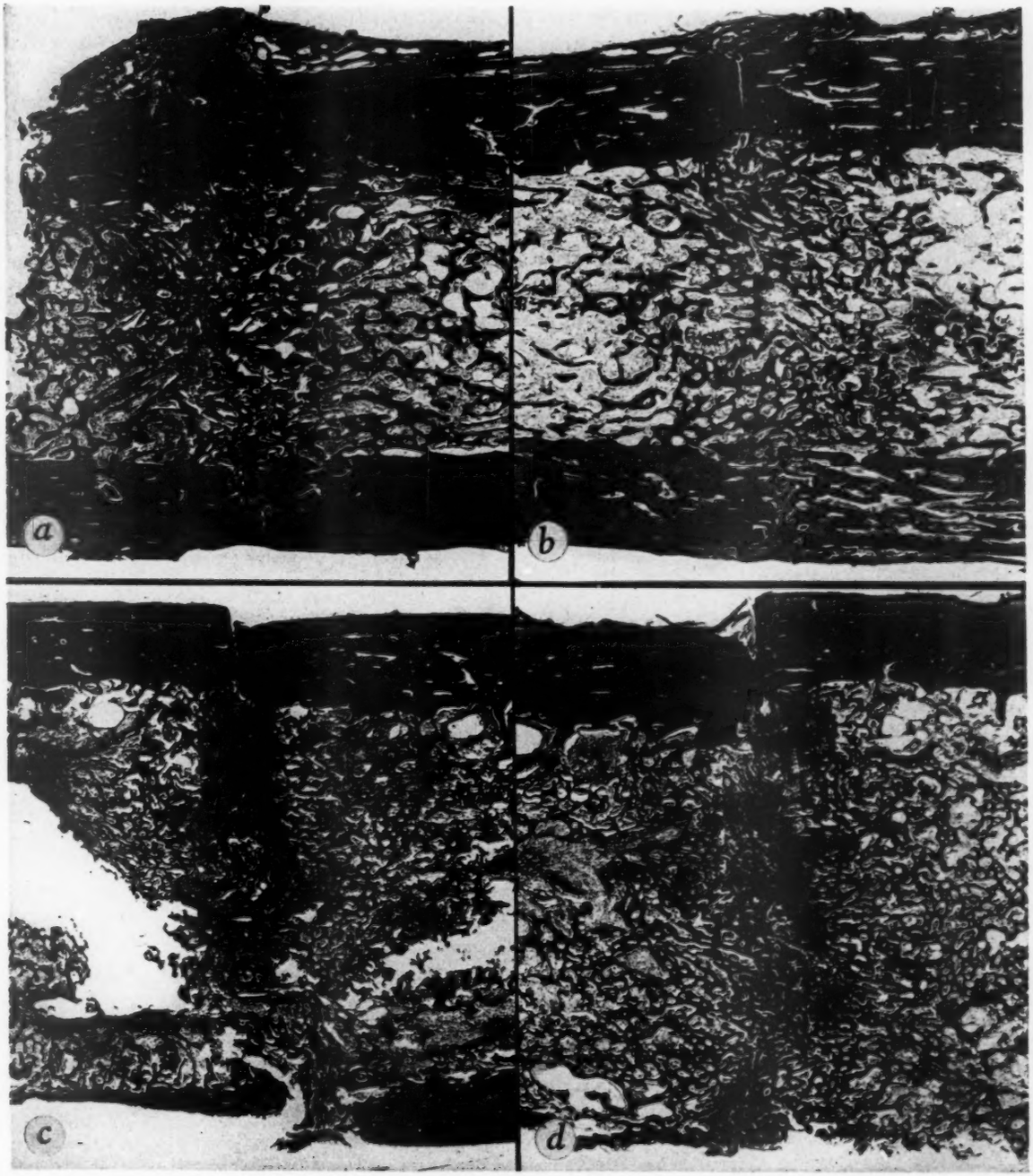

FIG. 6. Sections through fracture sites shown in Figure 5, in dog 8 thirty-three days after osteotomy (*a* and *b*, hematoxylin and eosin × 8), and in dog 10 twenty days after osteotomy (bony union in both femurs) (*c* and *d*, hematoxylin and eosin × 9). (*a*) Femur shown in Figure 5*a*; control plate. Bony union. (*b*) Femur shown in Figure 5*b*; compression plate. Bony union. (*c*) Femur shown in Figure 5*c*; control plate. (*d*) Femur shown in Figure 5*d*; compression plate. For details of application of plates see Figure 5 and text.

heretofore we have not realized the importance of attaining rigid immobilization and precise anatomic reduction and have not strived for it. With the realization of the advantages to be gained by better controlling these two factors we are motivated to do our utmost to attain these ends. Furthermore, most fractures in human beings can have the added protection of a cast which was not used in these dogs. We believe that by rigidly holding bone fragments and closely approximating them, the phenomenon of induction may stimulate osteogene-

sis and a process of union may proceed by first intention in contrast to secondary intention. If this is reasonable, then it follows that all fractured bones, whether phalanx or femur, should unite in the same period of time if the blood supply to each fragment is good and comparable and rigid immobilization with precise reduction of the fragments can be maintained. This means that a femur should unite in about four weeks. The over-all results of group 1, compared to group 2, are consistent with this reasoning when we consider the average time required for union in group 1 was 134.8 days when the fragments were poorly immobilized, compared to 44.4 days when they were immobilized better. Furthermore, it must be remembered that this was accomplished without benefit of a plaster cast.

Two important factors to fracture union are blood supply and induction. By good blood supply, we mean obtaining a rich capillary bed which infiltrates the fracture hematoma. Motion of the fragments will rupture the new capillaries and will result in the formation of tissue requiring less blood supply than bone callus, namely, fibrocartilage and fibrous tissue. This tissue does help to immobilize the fragments and thus to pave the way for its eventual replacement by bone. Close approximation of fragments results in many points of bony contact and thus encourages osteogenesis by induction.

Finally, a word should be said about absorption of bone about a fracture site. If absorption of the ends of the fragments occurs with the resultant shortening, then rigid immobilization would result in the formation of a gap. This did not occur in those fractures in which rigid immobilization was maintained, as in group 2. In group 1, however, the bones had shortened somewhat more if they were ununited when the dog was killed than if they were united, and shortening was more prevalent on the control side where the screws were not turned tightly to effect rigid fixation. This is consistent with Eggers' contention that absorption is taking place and being replaced by new bone at the same time, and only those fractures going to delayed union or non-union actually experience a shortening of the fragments, since the absorbed bone is not being replaced at the fracture site as it should be. When the fragments are rigidly held in close contact, the absorbed bone will be replaced without a resulting fracture gap. This statement is based on the fact that when the fragments were rigidly immobilized and closely approximated, union occurred early and without evidence of widening of the gap between the cortices. Microscopic sections from dog 2 (Fig. 4*a* and *b*) showed absorption about the fragments on the right where union was slow; but on the left, where union was present, the sharp edge of the saw cut through the cortices could still be seen and there was no evidence of absorption whatsoever.

SUMMARY AND CONCLUSIONS

After osteotomy of the femurs in two groups of dogs, a compressing plate or a Collison plate was applied to maintain approximation and immobilization. No bone necrosis was produced by the compression plate used. From study of healing the following conclusions seem warranted:

1. Compression *per se* does not stimulate osteogenesis when applied to osteotomized femurs of the dog.
2. Compression does increase immobilization and close approximation of the fragments, and when these two factors are rigidly maintained the period of healing for a fracture can be markedly reduced.
3. Close approximation of the fragments allows the phenomenon of induction to stimulate osteogenesis.
4. Rigid immobilization favors the early invasion of capillaries into the organizing hematoma about the fracture.
5. Close approximation and rigid immobilization of the fragments result in union by primary intention in contrast to union by secondary intention, which is characterized by large amounts of cartilage and external callus formation.
6. Bone absorption about the fracture seems to occur only when a process of slow or delayed union is going on.

If a compressing bone plate has a place in clinical fracture work, it would be for its ability to provide better immobilization and closer approximation of the fragments than other methods. However, under experimental conditions these two factors can be as well maintained without a compressing bone plate.

Acknowledgment: The authors are grateful to Dr. J. H. Grindlay and the staff of the Section

of Surgical Research for their advice and the use of their facilities in altering this instrument.

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A Survey of Gastric Surgery for Ulcer and Neoplasm

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THE record of technical achievement in gastric surgery during the past seventy-five years is an enviable one. The first successful gastroenterostomy was performed in 1881 by Wolfler. The first successful gastric resection (pylorectomy) was performed by Billroth in 1881. Despite the concept of total gastrectomy as a relatively recent surgical innovation, it should be recalled that the first total gastrectomy with patient survival was performed by Schlatter in 1897.

Surgical practice is influenced by respect for statistical results. These may be achieved by an individual or by a specific surgical group. It behooves every such surgical group to analyze critically its own particular experience in any specific endeavor.

The current study represents a completely unselected group of consecutive patients undergoing gastric or gastroduodenal surgical procedures in a large voluntary hospital during the ten-year period 1947 through 1956. These cases included ward, private and semi-private patients, and the operations were all performed directly by or under the supervision of members of a surgical staff, all of whom had had adequate and acceptable training in intestinal surgery. We were concerned with the nature of procedures performed in terms of the disease processes present, with preoperative qualifying disturbances, with postoperative complications and with deaths. No attempt was made to analyze any surgical or physiological results beyond the hospital course of the operated patient. We have divided our group into those representing (1) operative procedures on patients with gastric neoplasms; and (2) operative procedures on patients presenting gastroduodenal ulcerations. There is a further breakdown of the latter group into surgical emergencies, that is, instances of perforations and of exsanguinating hemorrhages, and "electively treated" lesions.

RESULTS OF ANALYZED MATERIAL

Tables I through XIV exhibit the composite results of the analysis of each individual case.

A brief abstract of the course of each nonsurvivor accompanies the respective listings.

MALIGNANT TUMORS OF THE STOMACH

The hospital experience with gastric cancer is summarized in Tables I through III.

Our group has operated upon 163 patients with malignant gastric tumors of which six were lymphosarcomas and 157 were carcinomas. Eleven cases (6.7 per cent) were interpreted as representing benign disease on preoperative studies.

In general, our results regarding resectability, complications and mortality have about paralleled those of many other representative American clinics. The majority of our patients who underwent resection with cure in mind were subjected to "radical" subtotal gastric resection occasionally incorporating neighboring viscera.

We have been surprised to note how few patients with gastric cancer we have had occasion to operate upon. We suspect that a certain number of patients with this disease are regarded as not being candidates for surgical exploration on the basis of the local physician's clinical estimate of metastatic disease or, perhaps in some few cases, on his estimate of the futility of surgical treatment in gastric cancer. Our record of resectability with cure in mind (38 per cent) reflects some of the problems in

the current management of gastric cancer. Although total gastrectomies and block visceral and node resections have been performed with more aggression in recent years, we undertake supraradical dissections with guarded enthusiasm. Estimated cancer salvage is still discouraging because nothing short of surgical herosim is necessary to extirpate all the centrifugal nodes of the gastric lymphatic drainage systems [2,8,10].

In our group of sixty-two operable tumors, we have had five non-survivors, three of whom were patients subjected to total gastrectomy. Major causes of death included one of each of the following: traumatic coronary artery rupture, pulmonary embolism, sepsis, small bowel fistula and atelectasis.

In the inoperable group of 101 patients, there were ten hospital deaths. Three of the eleven patients on whom palliative resections were performed in this group died; the cause of death in one was pulmonary embolism on the tenth day. The remaining nine deaths in the "inoperable" group were due to progression of disease and complications thereof occurring in the hospital up to seventy-six days postoperatively.

TABLE I

MALIGNANT TUMORS OF THE STOMACH: ANALYSIS OF PROCEDURES PERFORMED

No. of cases	163	
Females	55	
Males	108	
Preoperative diagnosis of benign disease		11 (6.7%)
Resectability with cure in mind in operated cases		62 (38.0%)
Operations for gastric cancer with cure in mind	62	
Subtotal gastrectomy (with vagectomy)	50	
Esophagogastrectomy	5	
Total gastrectomy	7	
Cases regarded as inoperable at exploration, treated as follows:	101	
Gastrostomy	13	
Gastroenterostomy (with vagectomy)	24	
Exploration with or without biopsy	53	
Palliative resection	11	
Operative deaths in 101 inoperable cases		10 (9.9%)
Operative deaths in 62 cases resected with cure in mind		5 (8.1%)

PERFORATED PEPTIC ULCERS

Tables IV and V illustrate our experience with perforated ulcers. Only 10 per cent of our group had been hospitalized for medical and/or surgical treatment of ulcers prior to the episode of perforation.

TABLE II

MALIGNANT TUMORS OF THE STOMACH: MAJOR COMPLICATIONS POSTOPERATIVELY

Wound disruptions	3
Wound infections	7
Pulmonary complications	22
Thromboembolism of extremities	2
Pulmonary embolism (all 3 died)	3
Delayed function of stoma (1 required re-exploration)	6
Postoperative intestinal obstruction (1 required re-operation; survived)	2
Postoperative duodenal stump disorder	0
Anastomotic leaks	3
Esophagogastrectomy (by radiograph only); no surgery; survived	
Esophagogastrectomy; empyema, right pleural space; drained; survived	
Total gastrectomy; subphrenic abscess; died	
Coronary occlusion (1 died)	2
Cerebral accident	1
Jaundice following operation (serum hepatitis contributed to loss of 1 patient)	4
Subphrenic abscess (1 died)	2
Small bowel fistula (contributed to loss of patient)	1

TABLE III

MALIGNANT TUMORS OF THE STOMACH: HOSPITAL DEATHS OCCURRING ONE TO SEVENTY-SIX DAYS POSTOPERATIVELY

Non-resectable group	10
Resectable group	5

Analysis of deaths in resectable group:

1. Total gastrectomy; died 2nd day of coronary artery rupture, traumatic; autopsy performed
2. Total gastrectomy; died 76 days postoperatively of leak from esophagojejunostomy; sepsis and carcinomatosis
3. Total gastrectomy; died 5th postoperative day of pulmonary embolism
4. Radical subtotal gastrectomy; wound dehiscence early in postoperative course; complication treated by packing; high small bowel fistula developed and was gradually closing; patient exhibited picture of serum hepatitis and died in coma 8 wk. following resection
5. Transthoracic esophagogastrectomy; died on 3rd postoperative day of acute and chronic bronchitis with occlusion by mucopurulent material, acute fibrinous pleuritis and atelectasis of left lung; autopsy performed

Complications have been gratifyingly few. It was necessary to reoperate upon two patients, one for pyloric obstruction and the other for subphrenic abscess. Two of the seventy patients died. One patient probably was beyond salvage on admission; perforation had occurred twenty hours previously. The second patient died of hemorrhage followed by renal shutdown. Our operative loss of 2.8 per cent for seventy perforated ulcers is very low when compared to that reported by observers in comparable institutions [5,6].

Regarding gastroduodenal ulcerations straddling the pyloric ring, we have not elected to perform definitive surgery (e.g., beyond emergency repair) in the cases of perforations. In general, we have seen fit to treat only the perforation and, if indicated, to arrange for the patient's return later for definitive surgical therapy. Our group has seen relatively few cases of perforated ulcers in which we regarded the local situation as permitting adequate duodenal dissection and eventual secure stump closure. Perhaps future experiences will convince us that our attitude has been one of unnecessary caution [5,12].

TABLE IV
PERFORATED PEPTIC ULCERS: ANALYSIS OF CASES

No. of cases	70
Females	12
Males	58
Previously hospitalized for medical treatment	6
Previously hospitalized for surgical treatment of ulcer	1
Mistaken diagnosis (3 appendicitis, 1 diverticulitis)	4
Estimated location of ulcer at operation:	
Prepyloric	20
Duodenal	46
Paracardiac	3
Stomal (gastroenterostomy stoma)	1
Operation performed:	
Gastrorrhaphy or duodenorrhaphy	68
Duodenorrhaphy plus gastrojejunostomy (1 immediate; 1 on 16th postoperative day)	2

TABLE V
PERFORATED PEPTIC ULCERS: COMPLICATIONS AND DEATHS

Wound infections	5
Pulmonary complications	8
Phlebothrombosis of extremities	1
Postoperative hemorrhage (1 died)	2
Pyloric stenosis (relieved by gastrojejunostomy, 16th day)	1
Postoperative peritonitis (died)	1
Subphrenic abscess, right (drained 16th day with recovery)	1
Deaths	2
Hemorrhage from plication site plus lower nephron nephrosis; died 10 days postoperatively	
Peritonitis following surgery for perforation which occurred 20 hr. before hospitalization; died 9th day postoperatively	

TABLE VI
EMERGENCY SURGERY FOR MASSIVE HEMORRHAGE: ANALYSIS OF CASES

No. of cases	48
Females	10
Males	38
Previous hospitalization for medical treatment (1 for pain; 1 for hemorrhage)	2
Previous hospitalization for surgical treatment (1 perforation; 2 gastroenterostomies)	3
Location of ulcer:	
Lesser curvature ulcer, paracardiac	2
Lesser curvature ulcer, prepyloric	14
Duodenal ulcer	31
Anastomotic ulcer	1
Operative procedure:	
Local excision of gastric ulcer	1
Plication of gastric ulcer	1
Gastrotomy without other definitive surgery	2
Gastrectomy (1 case with vagectomy)	44

EMERGENCY SURGERY FOR MASSIVE HEMORRHAGE

It should be emphasized that this group represents patients who were admitted with catastrophic bleeding or who bled massively while under hospital observation for ulcers. In these patients, restoration of 2,000 cc. of whole blood in any single twenty-four–hour period failed to result in the impression of the combined medical-surgical team that clinical improvement had been realized and/or that bleeding had ceased.

The group of patients whom we have regarded as candidates for emergency operations for exsanguinating hemorrhage from a gastric or a duodenal ulcer illustrates a fundamental surgical principle. As in many other anatomical regions, one treads much safer ground in treating the disease of the organ in its quiescent stage on an elective basis under conditions optimum for surgeon, patient and anesthesiologist. The significant increase in surgical

risk, with respect to morbidity and mortality (Tables VI through VIII), in the patient with exsanguinating hemorrhage from an ulcer is undeniable. However, it is difficult to visualize how this situation can be modified in this restricted category, when one considers that only five patients in this group had previously been examined or treated for ulcer as hospital inpatients. In other words, forty-three of forty-eight patients were admitted with massive hemorrhage as the first serious symptom of ulcers warranting hospitalization.

The location of the ulcers at operation or at postmortem examination is designated in Table VI. By and large, subtotal gastrectomy was the preferred surgical procedure performed. The individual operator usually removed the bleeding lesion with the resected stomach when the actual site of hemorrhage was anatomically visualized.

Complications encountered in this group are designated in Table VII. Of extraordinary importance was the occurrence of postoperative hemorrhage. Six patients experienced this complication and all died. Four and possibly five of these six patients are known to have had the ulcer left *in situ*. It would appear that we must guard against a non-aggressive attitude at the operating table in the management of this type of patient. We have learned that further hemorrhage in the postoperative period in these patients is a grave complication. In these poor risk patients we were fortunate in having no deaths attributable to the complication of duodenal stump leak. In six patients this serious complication developed, necessitating an unusually long period of hospitalization.

The incidence of the complications of sepsis and of further hemorrhage following surgery on these desperately ill patients is tremendously disproportionate to that experienced when gastroduodenal ulcerations are treated on an elective, interval basis (compare Tables VII and XIII). More important, the surgical mortality after operations on this particular group follows the same pattern. Among these forty-eight patients there were eleven deaths, or a mortality rate of 22.9 per cent. In summary, six patients died of postoperative bleeding (as indicated previously), including one patient who also had peritonitis; two patients died of aspiration of gastric content, one of a coronary occlusion, one of acute pancreatitis, and one of peritonitis secondary to a gastroenterostomy leak. Four of the eleven non-survivors were over seventy years of age, and in three of these patients operation was undertaken as a preoperatively avowed heroic measure.

There is reason to suspect that this dis-

TABLE VII
EMERGENCY SURGERY FOR MASSIVE HEMORRHAGE: COMPLICATIONS

Wound infections	6
Wound disruptions (resutured)	2
Pulmonary complications	11
Phlebothrombosis of extremities	3
Pulmonary embolism (non-fatal)	1
Transfusion hepatitis	2
Acute pancreatic necrosis (reoperated; died)	1
Postoperative hemorrhage	6
(All died; 4, possibly 5, known to have had original bleeding lesion left *in situ;* only 1 patient reexplored, for sepsis accompanying hemorrhage)	
Postoperative duodenal stump leaks (no deaths)	6
Prolonged drainage; healed without further surgery	2
Subhepatic collection drained by reoperation	2
Subphrenic abscesses, slough of entire pancreas, liver abscesses; drained	1
Catheter duodenostomy; electrolyte imbalance; finally well	1
Postoperative peritonitis (1 reoperated; both died)	2
Postoperative obstruction	2
(1 volvulus; reoperated 7th day; recovered; 1 possibly due to peritonitis; died of aspiration)	
Aspiration at end of operation (died ½ hr. after incident)	1
Acute myocardial infarct (died)	1
Lower nephron nephrosis plus postoperative hemorrhage (died)	1

tressing ten-year figure for losses following operation for exsanguinating hemorrhage does not reflect the experience of the past three years because a policy of better teamwork between the medical and surgical consultants has been developed in the management of these patients. Generally, under this policy, there has been a tendency toward earlier operation.

GASTRODUODENAL ULCERATIONS TREATED BY ELECTIVE SURGERY

Our experiences in the surgical management of patients with ulcers treated electively have been gratifying, particularly when contrasted with the previously described group operated upon as emergencies because of exsanguinating hemorrhage.

One interesting facet of the age distribution in this group (Table IX) is that more than 20

TABLE VIII

EMERGENCY SURGERY FOR MASSIVE HEMORRHAGE: ANALYSIS OF DEATHS*

Case No.	Sex and Age Decade	Operation	Complications	Treatment	Residual Pathology
1	F, 70's	Gastrotomy	Continued hemorrhage	Transfusions	High lesser curvature ulcer undetected at operation; autopsy performed
2	F, 60's	Gastrotomy	Continued hemorrhage	Transfusions	Gastrojejunal ulcer undetected at operation; autopsy performed
3	M, 40's	Gastrectomy	Continued hemorrhage	Transfusions	Ulcer left *in situ;* autopsy performed
4	M, 50's	Gastrectomy	Secondary hemorrhage; gastrojejunostomy leak	Re-explored twice for resuture and drainage	Perforations of jejunum and stomach; subphrenic abscess
5	M, 40's	Gastrectomy	Continued hemorrhage; lower nephron nephrosis	Artificial kidney	Ulcer not in stomach specimen; questionable cirrhosis with varices
6	M, 30's	Gastrectomy	Continued hemorrhage	Transfusions	Postbulbar bleeding ulcer left *in situ;* autopsy performed
7	F, 70's	Gastrectomy	Gastrojejunostomy leak	Gastric suction, antibiotics	Peritonitis
8	M, 80's	Gastrectomy	Acute coronary occlusion	.....	Myocardial infarction
9	M, 50's	Gastrectomy	Aspiration of gastric contents ½ hr. after operation	Bronchoscopy	Aspiration pneumonitis
10	M, 40's	Gastrectomy	Aspiration of gastric content following intestinal obstruction	Tracheostomy	Pulmonary edema
11	M, 70's	Gastrectomy	Obstructive jaundice and ileus	Re-explored	Acute necrotizing pancreatitis

* Eleven of forty-eight patients died (22.9 per cent).

per cent of the 402 electively operated patients were over sixty years of age. On the other hand, only six patients of this entire group were under thirty years of age.

TABLE IX

GASTRODUODENAL ULCERATIONS TREATED BY ELECTIVE SURGERY: AGE AND SEX DISTRIBUTION

Sex distribution:	
No. of cases	402
Females	84
Males	318
Age distribution:	
20–29	6
30–39	56
40–49	121
50–59	133
60–69	71
70–79	15

Table x shows that over 50 per cent of these patients had required hospitalization previously for therapy of active ulcers. Seventy-two operative procedures had been performed previously upon sixty-two patients, (15 per cent of the total).

Thirteen of the 115 gastric lesions in this group were preoperatively interpreted clinically and roentgenographically as gastric cancer (11.3 per cent). Table XI shows that relatively few cases of anastomotic ulcers (and gastrojejunocolic fistulas) came to surgical attention in this period. These represent 3.5 per cent of electively operated cases of ulcer.

The procedures which our group saw fit to perform in these 402 patients are detailed in Table XII. Usually the procedure of choice, namely, partial gastrectomy, in the hands of the various members of our group, has consisted of resection of 60 to 75 per cent of the distal stomach and terminolateral gastrojejunostomy following a Hofmeister fashioning of the lesser curvature of the residual gastric pouch. A few Billroth 1 procedures have been performed but these generally have not

appealed to us because we have not been particularly troubled by the complications which have prompted the revitalization of this operation, namely, irreversible nutritional alterations and perhaps an unusual incidence of the "dumping" syndrome. We do constantly

TABLE X
GASTRODUODENAL ULCERATIONS TREATED BY ELECTIVE SURGERY: PREOPERATIVE EVALUATION OF 402 PATIENTS

Previous hospitalizations		223 (55%)
Medical		161 (40%)
Surgical		62 (15%)
Perforation	53	
Gastroenterostomy	13	
Pyloroplasty	1	
Local excision	2	
Sleeve resection	1	
Gastroenterostomy and closure of perforation	2	
Preoperative cardiac complications		38
Preoperative pulmonary complications		18

TABLE XI
GASTRODUODENAL ULCERATIONS TREATED BY ELECTIVE SURGERY: PATHOLOGIC DIAGNOSIS

Preoperative diagnosis of gastric cancer proved to be benign ulcer	13 of 115 gastric lesions (11.3%)
Lesser curvature ulcer, paracardiac	17
Lesser curvature ulcer, prepyloric	92
Greater curvature ulcer, benign	3
Duodenal ulcer	273
Hypertrophic gastritis (gastrotomy only)	3
Anastomotic ulcer	12
Gastrojejunocolic fistula	2

bear in mind the enviable record of those who are again bringing this choice of operation to our attention [9].

Gastroenterostomy was performed upon thirty-four patients; they were usually in an older age group and had stenosing lesions and low acid values. The majority of patients upon whom gastroenterostomy with abdominal vagectomy was performed represent a segment of a pilot study group of the years 1945 to 1947 which was undertaken to evaluate this particular procedure. However, in general, in the case of the "inoperable" ulcer with unforeseen massive edema and pancreatic penetration, we have occasionally reserved the privilege of performing vagectomy and gastroenterostomy rather than gastric resection which technically might endanger the life of a patient with an

TABLE XII
GASTRODUODENAL ULCERATIONS TREATED BY ELECTIVE SURGERY: OPERATIVE PROCEDURES

Gastrotomy (3 for hypertrophic gastritis; 2 for gastric ulcer diagnosed by biopsy)		5
Sleeve resection and local excision		1
Gastroenterostomy (4 died)		34
Gastroenterostomy with abdominal vagectomy		35
Subdiaphragmatic vagectomy for anastomotic ulcer		3
Transthoracic vagectomy for anastomotic ulcer		4
Gastrectomy (6 died)		318
Polya antecolic	13	
Polya retrocolic	18	
Hofmeister antecolic	40	
Hofmeister retrocolic	200	
Billroth II antecolic	9	
Billroth II retrocolic	17	
Billroth I	2	
With abdominal vagectomy	15	
Bancroft procedure	3	
Radical subtotal gastrectomy with node dissection	1	
Esophagogastrectomy with dissection of nodes and other viscera (1 died)		2

TABLE XIII
GASTRODUODENAL ULCERATIONS TREATED BY ELECTIVE SURGERY: COMPLICATIONS

Pulmonary complications	48
Phlebothrombosis of extremities	6
Thromboembolism, lungs	4
Delayed function of stoma with retention	19
Stomal complications with re-exploration (4 following gastrectomies with 2 non-survivors; 2 following gastroenterostomies)	6
Postoperative hemorrhage (2 following gastrectomy, recovered; 3 following gastroenterostomies, died)	5
Pancreatic fistula	3
Postoperative duodenal stump disorders (no deaths) (6 leaks, 2 reoperated; 4 catheter duodenostomies, 1 reoperated)	10
Subphrenic abscess	2
Postoperative peritonitis (2 deaths, both postgastrectomy; 1 reoperated)	2
Postoperative intestinal obstruction (2 deaths; 2 postgastrectomy; 1 postgastroenterostomy; 3 reoperated)	3
Posttransfusion hepatitis	2
Colonic fistula (closed surgically with recovery)	1
Cardiovascular accident (1 died; also had other complications: sepsis, wound dehiscence)	2
Cardiac complications (1 died of cardiac arrest at closure)	2
Acute cholecystitis	1
Antibiotic reactions (1 death)	3

TABLE XIV

GASTRODUODENAL ULCERATIONS TREATED BY ELECTIVE SURGERY: ANALYSIS OF DEATHS*

Case No.	Sex and Age Decade	Operation	Complications	Treatment	Residual Pathology
1	F, 50's	Gastrectomy (Hofmeister antecolic)	Peritonitis, wound dehiscence, cerebral accident	Re-explored; jejunostomy	Hemolytic Staphylococcus aureus infection
2	M, 70's	Gastrectomy (Hofmeister antecolic)	Efferent loop obstruction	Re-explored; lysis of adhesions and enteroenterostomy	Wound disruption, gastric hemorrhage
3	M, 60's	Gastroenterostomy (retrocolic)	Massive hemorrhage	Transfusions	Bleeding ulcer(?)
4	M, 50's	Gastrectomy (Billroth II antecolic)	Stomal obstruction	Re-explored twice; lysis of adhesions and enteroenterostomy, later jejunostomy	Uremia
5	M, 50's	Gastrectomy, (Hofmeister antecolic) pancreatico- and choledocho-jejunostomies	Peritonitis	Antibiotics and transfusions	Peritoneal hemorrhages, pancreatic necrosis, necrotizing cholecystitis (autopsy)
6	M, 60's	Gastroenterostomy (antecolic)	Massive hemorrhage	.....	Hemorrhage from gastric ulcer penetrating into pancreas and pulmonary infarcts (autopsy)
7	F, 60's	Gastrectomy (Hofmeister antecolic)	Cardiac arrest at closure of abdomen	.....	Myocardial infarction (cardioscope)
8	M, 60's	Gastroenterostomy (retrocolic)	Efferent loop obstruction	Re-explored; gastrotomy and lysis of adhesions	Herniation of small bowel spur into stomach due to adhesions of small bowel mesentery to colon (autopsy)
9	F, 60's	Gastrectomy (Hofmeister retrocolic)	Stomal obstruction	Re-explored; anterior gastroenterostomy	Peritonitis (autopsy)
10	M, 60's	Gastrectomy (radical proximal with esophagogastrostomy	Uncontrollable diarrhea and electrolyte imbalance	Fluid balance measures, erythromycin, steroids	Diffuse pseudomembranous and ulcerating enterocolitis (autopsy)
11	F, 70's	Gastroenterostomy (retrocolic) and cholecystectomy	Hemorrhage, gastric retention	Transfusions, gastric suction	Duodenal ulcerations and infarcted area of jejunum (autopsy)

* Deaths following elective surgery for ulcer	11 of 402 (2.74%)
Esophagogastrectomies	1 of 2
Gastroenterostomies (includes 35 with vagectomy; no deaths)	4 of 69 (5.8%)
Subtotal gastric resections	6 of 318 (1.9%)
Hofmeister retrocolic type	1 of 200 (0.5%)

otherwise benign lesion. For example, when at the operating table one is still not committed to perform gastrectomy, vagectomy and gastroenterostomy in our estimation are to be preferred to gastric resection with catheter duodenostomy. In four patients it was deemed advisable to perform catheter duodenostomy because of a duodenal stump remnant which proved impossible to close properly [3]. These patients eventually left the hospital after a prolonged convalescence.

Table XIII is a self-explanatory résumé of complications encountered in these patients. Again it is apparent that stomal complications

requiring re-exploration and hemorrhage following operation are of serious significance. The same conclusion is warranted in the instances of postoperative peritonitis and small intestinal obstruction. In view of the disturbing experience of others with postoperative duodenal stump leaks [*1,14*] and pancreatic fistula, we have perhaps been fortunate regarding these particular complications. Of six patients with stump leaks, two requiring reoperation, all six eventually recovered. In three patients a pancreatic fistula developed and all three healed on non-operative measures.

Of the total 402 cases of ulcer operated upon electively, eleven patients died. This represents an over-all mortality rate of 2.74 per cent. This total includes four non-survivors among the total of thirty-four patients subjected to gastroenterostomy only. The procedure of choice, namely, distal subtotal gastric resection, in our hands bore a mortality rate of 1.9 per cent or six deaths in 318 cases. With our most commonly utilized type of gastrectomy, e.g., the Hofmeister procedure with retrocolic gastroenterostomy, we have lost but one of 200 patients, corresponding to a mortality rate of 0.5 per cent. Our record compares very favorably with the experience of others [*4,7,11,13*].

Case summaries of the eleven patients who died following elective operation for gastroduodenal ulceration are included in Table XIV. The major causes of death were as follows: In the patients upon whom only gastroenterostomy was performed, three died of hemorrhage and one of obstruction of the efferent loop of the jejunum. Of the seven losses in the gastrectomized patients, two died of peritonitis, two of stomal obstruction, one of efferent loop jejunal obstruction, one of cardiac arrest and one of pseudomembranous enterocolitis.

SUMMARY AND CONCLUSIONS

1. Analysis was made of 683 patients who underwent gastric surgery in a voluntary hospital in a ten-year period. The cases were studied in terms of pre- and of postoperative complications, operative procedures performed and deaths among four groups. The four groups were divided into: (1) gastric neoplasms; (2) gastroduodenal ulcerations with perforation; (3) gastroduodenal ulcerations with exsanguinating hemorrhage; and (4) gastroduodenal ulcerations treated electively.

2. Experiences with gastric cancer regarding resectability with cure in mind remain discouraging. Only 38 per cent of this group of 163 patients were considered candidates for curative resection.

3. The surgical treatment of perforated gastric and duodenal ulcers has been simple closure. With this method of management our mortality rate was 2.8 per cent of seventy patients.

4. The patients with ulcers and exsanguinating hemorrhage reflected a disproportionate risk regarding postoperative complications, such as further serious hemorrhage and sepsis, with a disturbing mortality rate of 22.9 per cent of forty-eight patients.

5. Gastric resection to the extent of 60 to 75 per cent of the stomach remains the procedure of choice for the interval surgical treatment of benign gastroduodenal ulceration. Of 318 gastrectomized patients, the operative mortality rate was 1.9 per cent. The Hofmeister gastrectomy with retrocolic gastrojejunostomy, our procedure of choice, was performed upon 200 patients in whom the mortality rate was 0.5 per cent.

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Duodenostomy in Gastric Resection for Duodenal Ulcer

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FOR many years, the "bête noire" of gastric surgeons has been the successful management of the duodenal stump that does not lend itself freely to good closure during gastric resection. With but few exceptions, this is a problem concerned with the surgery of duodenal ulcer. Dense scarring about a partially healed or obstructing ulcer causes some difficulty in dissection but real hazards develop in attempting to free the duodenum with an active ulcer associated with widespread induration and engorgement of the intestinal wall, especially if the pancreas has become involved. Because of the difficulty in obtaining a satisfactory closure of the inflamed duodenal stump, many plans of management have been suggested. These include pyloric exclusion, staged gastric resection, gastroenterostomy with or without vagotomy, the Wangensteen segmental gastric resection and the Finsterer resection, modified by Jakabovici [*1*] and later known as the Bancroft procedure or mucoclasis. When there is a posterior ulcer burrowing into the pancreas, Nissen [*1*] suggested division of the bowel and suture of the anterior duodenal wall to the distal edge of the ulcer followed by drainage of the ulcer area exteriorly.

Although it is not frequently recognized, probably one of the most morbid of postoperative complications in gastroduodenal operations is acute postresection pancreatitis. Reinhoff [*2*] and others have made note of this circumstance. In our own experience, the principal cause of death following surgery for duodenal ulcer has been necrotizing pancreatitis, beginning about the site of a resected penetrating duodenal ulcer. At one time the duodenal stump was often buried into the head of the pancreas which served as a buttress to the suture line. We believe this practice may lead to subclinical but painful postoperative pancreatitis. It is conceivable that this pancreatitis may in itself contribute to the breakdown of the apparently properly sutured duodenal stump.

Failure of the suture line in the duodenal stump leads to acute chemical peritonitis, which is caused by flooding of the peritoneal cavity with bile and pancreatic juice. When the peritoneal cavity is adequately drained early or when drains have been inserted at operation, a duodenal fistula is established as the stump of the duodenum begins to leak.

Placement of drains to the resected duodenal stump will not always prevent generalized peritonitis should a duodenal leak occur; however, it will give an early warning of what has happened and aid in localizing the inflammatory process. According to McEachern, Sullivan and Arata [*3*], a report of 179 cases of gastric resection by McKittrick stated that 50 per cent of the mortality was due to peritonitis attributed to duodenal leakage. The same writers cite Arola who reported ten deaths in thirteen cases of duodenal fistula following gastric resection. These figures emphasize the dangers of the insecure duodenal closure.

At this point it seems relevant to call attention to the proximity of pancreatic and biliary ducts to the most frequent sites of duodenal ulcer. Cattell and Warren [*4*] have recently cited the work of Millbourn, who in 200 dissections investigated the anatomy of the excre-

tory ducts of the pancreas and their relation to each other and to the bile ducts and duodenum. He emphasized that the distance of the major duodenal papilla from the pylorus varied from 5.5 to 9 cm., the average being 8 cm. The lesser papilla was cephalad to the major papilla at a distance varying from 0.9 to 3.5 cm. Millbourn further suggested, and we endorse his thought, that in the posterior duodenal ulcer these ducts frequently are injured. It is our belief that injured pancreatic and biliary ducts leaking their digestive juices may initiate the breakdown of the sutured duodenal stump.

TABLE I
PROCEDURE

Procedure	No. of Cases	
	Columbia Veterans Hospital	Other
Antecolic Hoffmeister	104	1*
Retrocolic Hoffmeister	20	..
Antecolic Polya	28	2†
Retrocolic Polya	8	..
Billroth 1	4	..
Totals	164	3

* Dr. George Benet's case.
† Dr. Karl Morgan Lippert's case.

In 1938 we were confronted with the problem of closing the duodenum during a difficult resection. We reasoned that duodenostomy, using a French catheter, carried a similar significance of a T-tube in the common duct, provided gastric resection was simultaneously performed to sidetrack the gastric juices. A persistent duodenal fistula, so greatly feared in the drainage of a perforated duodenal ulcer, requires the combined digestive juices of the duodenum and stomach to produce the destructive digestion of the abdominal wall. A similar incident occurred at a later date and was likewise successfully managed by catheter duodenostomy. It appears that Priestly in 1951 [5], Hoerr [7] in 1952, and Welch [8] in 1954, recognized the value of the catheter duodenostomy in the difficult duodenal stump and each published a report of his experiences. We have seen sporadic references to the technic by various surgeons in the past several years. A recent article by McEachern, Sullivan and Arata [3] states that they became interested in the use of the catheter duodenostomy in 1947 and from then until 1954, had performed the procedure eleven times in selected cases. Their patients ranged in age from thirty-seven to sixty years.

TABLE II
CAUSE OF DEATH

Patient	Days Postoperatively	Cause
C. B. S.	75	Necrotizing pancreatitis with abscess formation
I. H.	2	Pancreatitis, acute
J. A. D.	30	Undetermined
J. R. S.	4	Coronary thrombosis
A. M. C.	21	Uremia; pulmonary tuberculosis

All of them were men and the indications for surgery were hemorrhage, obstruction, perforation and intractability. These surgeons had used an anterior type of Polya gastric resection in each case. Their experience with the behavior of the tube duodenostomy is similar to our own which will be described herein.

The data included in this study are restricted to gastric resections for duodenal ulcers. It includes 164 cases from this hospital, one through the courtesy of Dr. George Benet* with whom one of us was associated in treatment of a patient, and two from personal experience. The patients ranged in age from twenty-one to seventy-seven years. They were all men. The duration of duodenal ulcer preoperatively was from six months to twenty-seven years. The reason for surgery was largely intractability although hemorrhage, either acute or repeated, was a frequent indication. The type of procedure used is shown in Table 1.

Five patients died in this series for a mortality rate of 2.9 per cent. Cause of death is shown in Table II.

Of these 167 patients, catheter duodenostomy was undertaken in twenty-one because of the extreme difficulty in preparing the duodenal stump for satisfactory closure. (Table III.) In several instances an attempt to perform duodenal closure in the accepted manner was

* Dr. George Benet, Surgical Consultant to the Veterans Administration Hospital.

TABLE III
DUODENOSTOMY

Patient	Age (yr.)	Indication for Surgery	Duration (yr.)	Reason for Duodenostomy
N. D. F.	38	Pain, previous perforation	8	Difficult closure
J. F. R.	31	Pain, bleeding	9	Poor closure
I. T. M.	51	Pain, obstruction	20	Difficult closure
C. M.	42	Pain, bleeding	3	Difficult closure
M. W. W.	32	Pain, bleeding	6	Difficult closure*
B. B. W.	33	Pain, obstruction	11	Difficult closure
J. W. N.	52	Pain, bleeding	4	Difficult closure
W. N. B.	52	Bleeding	9	Difficult closure
A. S.	45	Pain, obstruction	12	Poor closure
N. G.	38	Pain, acute ulcer	10	Poor closure*
B. C.	49	Pain, repeated perforation (× 3)	5	Duodenal stump could not be freed from scar tissue†
F. F.	35	Pain, obstruction	Undetermined	Impossible to close duodenal stump
J. C.	40	Pain, bleeding	Undetermined	Extensive posterior ulcer in pancreas that would not hold sutures
W. D.	36	Pain, perforation, obstruction	12	Difficult closure with involved pancreas
Mc. K. S.	59	Bleeding, pain	4	Difficult closure
J. E.	38	Intractable pain, repeated perforation, intestinal obstruction	9	Difficult closure‡
W. S. M.	62	Pain, obstruction	20	Difficult closure
C. H.	35	Pain	15	Difficult closure
S. R. N.	39	Pain, previous perforation	3	Difficult closure
H. C. B.	46	Bleeding, pain	5	Difficult closure, ulcer in pancreas
J. E. B.	65	Bleeding, pain	7	Difficult closure, some recurrent abdominal wall infection

* Dr. Karl Morgan Lippert's case.
† Dr. George Benet's case.
‡ This case described in detail in text. Repeated perforation both pre- and postresectional intestinal obstruction.

made but abandoned because sutures would not hold or the stump could not be inverted.

A summary of the experiences and method concerning this group of tube duodenostomies follows.

The process of performing tube duodenostomy during gastric resection is really very simple. (Figs. 1 and 2.) A No. 16 or 18 French urethral catheter is passed down into the duodenum through the open stump after dividing the gut distal to the pyloric ring. It is best to cut several additional holes near the tip of the catheter for adequate drainage. A purse string of chromic catgut is then passed about the circumference of the open duodenum and tied around the catheter. Then several additional inverting sutures are placed in the duodenal wall on each side of the catheter to partially invert the previous purse string closure. One of these second line sutures on each side of the catheter is left long to be used to fix the stump of the duodenum to the peritoneum at the time of abdominal closure. During the remainder of gastric resection the catheter is permitted to drain outside the wound. When abdominal closure is begun, a suitable stab wound is made in the abdominal wall just over the duodenum and the catheter brought out into the subcostal area. The stump of the duodenum is fixed to the peritoneum of the anterior abdominal wall to minimize the distance of free peritoneal cavity the catheter traverses. This diminishes the likelihood of a localized peritonitis or abscess should some duodenal juices leak around the catheter in the early postoperative period. In a few instances, two or three cigarette drains have been placed in proximity to the duodenal stump for fear of excessive leakage. Some surgeons have advised passing the catheter through a fold of omentum before contact with the anterior abdominal wall. We believe that by passing the catheter through the omentum there is considerable possibility of an abscess forming beneath the omentum, whereas fluid escaping from the duodenum would ordinarily

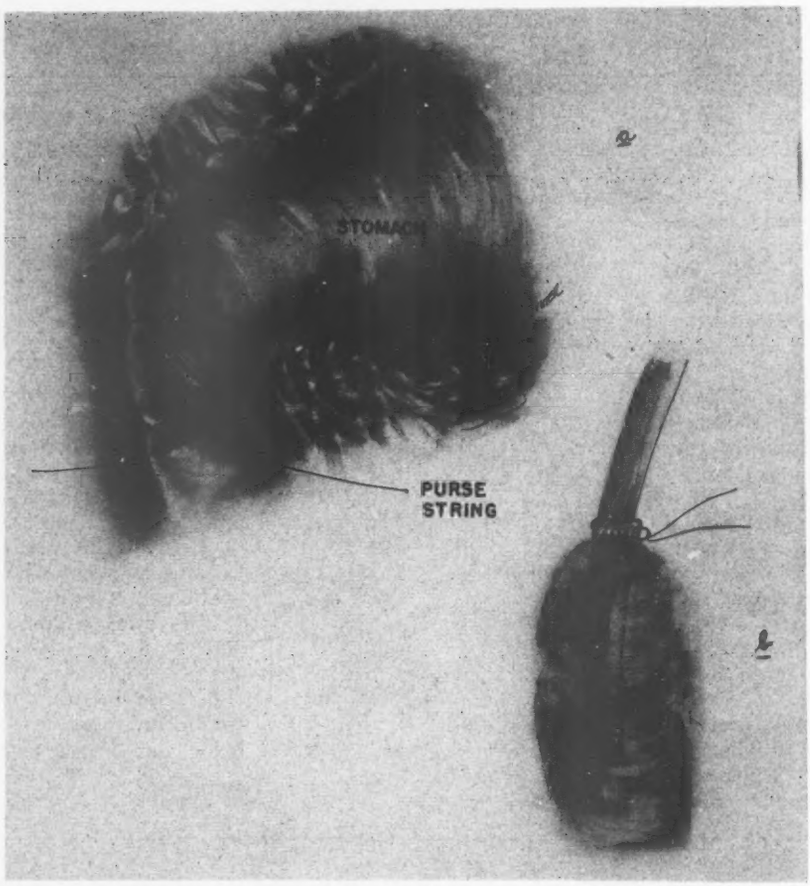

FIG. 1. (*a*) Schematic drawing showing division of gastrointestinal tract just distal with laying of purse string suture. (*b*) Purse string closure about French catheter inserted into the duodenum.

follow the catheter to the skin level. We have preferred to fold the omentum about the stump itself. The catheter is fixed to the skin by silk sutures and then connected to a drainage bottle. The amount and character of drainage is carefully examined. The discharge is calculated in the daily fluid intake and loss. About the tenth to sixteenth postoperative day, when gastrointestinal function has been well established, the silk skin suture is cut and the catheter allowed to "fall out." Ordinarily there may be slight drainage for a few days. With little exception, the drainage tract heals without incident. Occasionally it is necessary to apply a silver nitrate stick to granulation tissue which may form in this sinus tract or to spread the opening to allow a small amount of retained secretions in the abdominal wall to escape.

We would like to relate briefly an experience with a patient who had undergone six previous laparotomies before gastric resection. Three of these had been for duodenal perforation and three for intestinal obstruction. Duodenostomy was performed as part of the resection. Postoperatively the duodenal tube drained intestinal contents freely. After a week it became apparent that his jejunum was obstructed distal to the gastroenterostomy. The abdomen was reopened and enteroenterostomy performed because of the nature of the obstruction. The duodenostomy continued to drain intermittently until the enterostomy functioned well. We feel certain that duodenostomy contributed greatly to the successful outcome of this case which was not only a problem of difficult duodenal closure but also a problem of recurrent intestinal obstruction following gastric resection.

SUMMARY

The insecure duodenal stump remains the most significant source of anxiety to the

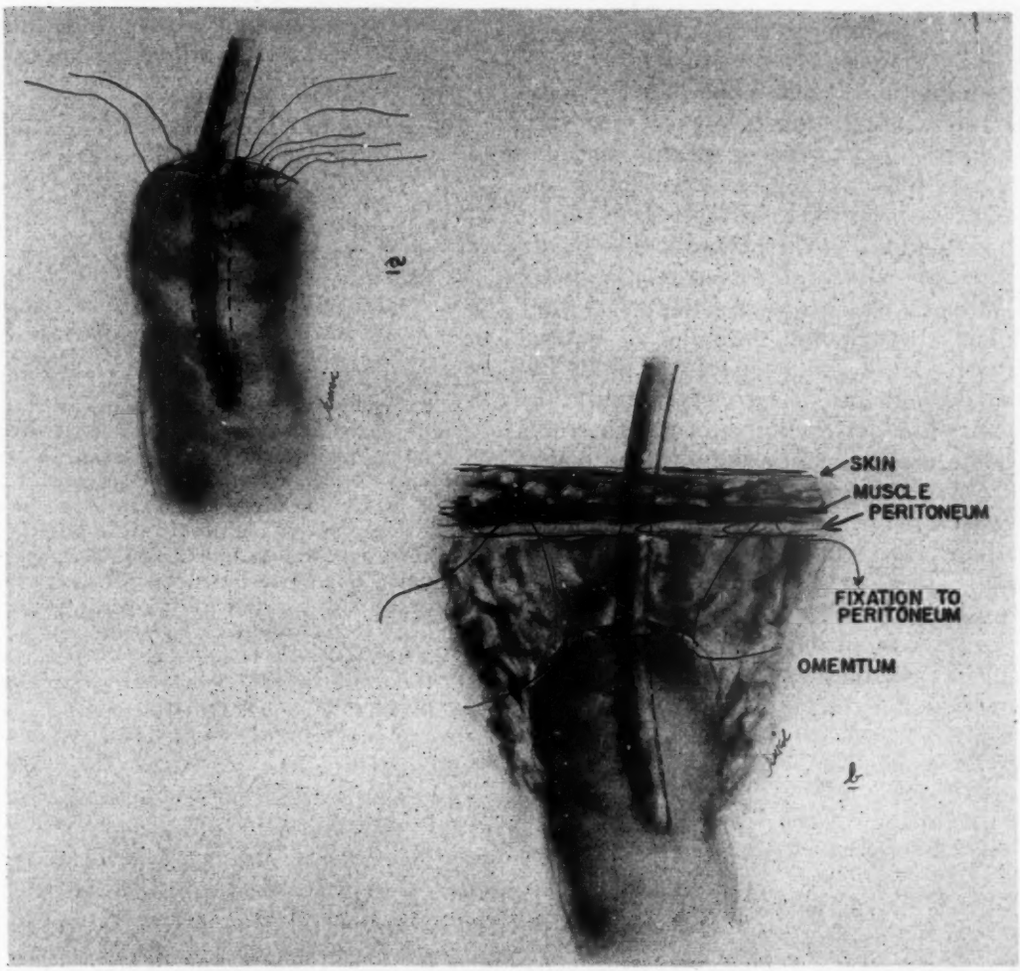

FIG. 2. (*a*) Reinforcing purse string suture with interrupted catgut layer. (*b*) Illustration showing method of attaching duodenal stump to undersurface overlying peritoneum for duodenostomy.

surgeon for the good of the patient after gastric resection. Leakage from the duodenal stump is the cause of extremely morbid and often fatal peritonitis. Extensive dissection of the duodenum, especially in penetrating ulcers, frequently leads to pancreatitis, sometimes mild but not infrequently of a severe necrotizing degree. Whether the pancreatitis causes the dissolution of the suture line or is secondary to duodenal leak is difficult to say. We feel certain that in some instances injured pancreatic and biliary ducts are responsible for some duodenal breakdowns. A method of catheter duodenostomy is described which is simple to perform with no greater complications to postoperative management than T-tube choledochostomy. Twenty-one cases of catheter duodenostomy are summarized in Table III. These duodenostomies were performed in a series of 167 unselected gastric resections for duodenal ulcer when it appeared that a safe closure of the duodenal opening could not be accomplished. The mortality rate for the entire series of resections is 2.9 per cent. No deaths occurred among the patients who underwent duodenostomy and there were no permanent fistulas. The only complication has been an occasional localized infection of the abdominal wall at the drainage site. It is our opinion that the low morbidity and death rate in this series of operations performed on unselected patients with complicated duodenal ulcer are definitely related to the use of duodenostomy when duodenal closure is insecure or very difficult. We do not believe that duodenostomy in this group of patients has significantly prolonged the period for which they require medical treatment postoperatively.

ADDENDUM

Since completion of this paper, Foley, Kilpatrick, and Crabtree [6] have presented the detailed embryology of the pancreas and its ducts. A case history is presented in which the duct of Santorini was the sole excretory channel for the body and tail of the pancreas. The head of the pancreas was drained entirely by the duct of Wirsung which was confluent with the choledochus through the ampulla of Vater. Inadvertent partial occlusion of the duct of Santorini during the process of freeing the duodenum, while performing subtotal gastrectomy, led to chronic pancreatitis in the body and tail. This disease was relieved by a secondary operation which adequately opened the duct of Santorini for free drainage into the duodenum.

The presentation by these authors lends support to the contention that duodenostomy, employing a catheter in the open end of the duodenum which is difficult to properly expose for safe closure, is an advantageous procedure in gastric resection for duodenal ulcer.

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Meperidine-Levallorphan in Anesthesia

STUDY OF USEFULNESS OF SUCH MIXTURES IN SUPPLEMENTATION OF NITROUS OXIDE-OXYGEN-THIOPENTAL ANESTHESIA

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ANALGETICS of the morphine type, combined with the narcotic antagonist levallorphan tartrate, were shown to be effective supplements to nitrous oxide-oxygen-thiopental sodium anesthesia. Thus, Radnay [1], who employed a mixture of levorphanol (levo dromoran®) tartrate and levallorphan in the 10:1 ratio, reported that this combination provided adequate supplementation without significant respiratory depression. Similarly, alphaprodine (nisentil®) hydrochloride, preceded by, or in combination with, levallorphan was used successfully by several groups of workers for supplementation. For instance, Foldes et al. [2] administered 0.02 mg./kg. of levallorphan, followed several minutes later by 1 mg./kg. of alphaprodine with subsequent fractional doses of this narcotic analgetic given as needed. These students reported that the use of levallorphan, which antagonized the respiratory-depressing effects of alphaprodine, made it possible to employ larger amounts of alphaprodine and thus to decrease considerably the doses of thiopental required; and that postoperative reactivity was superior to that observed with other technics. Kepes and Margolius [3] found that a premixed solution of alphaprodine and levallorphan in the 50:1 ratio, given by continuous drip for supplementation, provided satisfactory analgesia with only transient respiratory depression and prompt recovery from the anesthesia. The results reported by Stoelting and Hicks [4] and by Lipson and Bradford [5] are essentially in agreement with those observed by Foldes et al. [2] and Kepes and Margolius [3].

Reports on the usefulness of meperidine hydrochloride and levallorphan for supplementation had not appeared in the literature when we embarked on the present study, but we had been informed by Foldes [6] that 0.02 mg./kg. of levallorphan, followed several minutes later by 2 mg./kg. of meperidine, proved satisfactory for supplementation when he employed these compounds by the technic previously developed for the combined use of levallorphan and alphaprodine.

TABLE 1

AGE AND SEX DISTRIBUTION IN FOUR SERIES OF 100 PATIENTS EACH

Series I	Series II	Series III	Series IV
Meperidine Alone	Meperidine + Levallorphan (100:1)	Meperidine + Levallorphan (100:1.5)	Meperidine + Levallorphan (100:2)
Age Distribution			
6–81 yr (avg. 48 yr.)	15–81 yr. (avg. 50.4 yr.)	12–76 yr. (avg. 48.6 yr.)	6–77 yr. (avg. 44.85 yr.)
Sex Distribution			
38 males 62 females	26 males 74 females	35 males 65 females	28 males 72 females

It seemed of interest, therefore, to determine the optimal ratio of meperidine to levallorphan as supplementing agents, and trials were instituted accordingly.

CASE MATERIAL AND ANESTHETIC MANAGEMENT

The study comprised 400 surgical cases which were unselected except that only patients were included who were to receive nitrous oxide-oxygen-thiopental anesthesia. Premedication, given ninety minutes before surgery, consisted of 50 to 100 mg. of meperidine, 0.3 to 0.4 mg. of atropine sulfate or scopolamine hydrobromide,

TABLE II

TYPES OF OPERATIONS PERFORMED IN FOUR SERIES OF 100 PATIENTS EACH

Types of Operations	Series I Meperidine Alone	Series II Meperidine + Levallorphan (100:1)	Series III Meperidine + Levallorphan (100:1.5)	Series IV Meperidine + Levallorphan (100:2)
Craniotomies, laminectomies	4	5	6	6
Intrathoracic surgery	7	...	4	...
Herniorrhaphies	6	8	9	8
Breast biopsies	5	10	10	11
Radical mastectomies	3	7	6	5
Thyroidectomies	6	9	2	6
Vein ligations, skin grafts	4	3	8	8
Biopsies (other than breast biopsies), incisions	3	3	4	...
Proctologic procedures	2	4	1	1
Major gynecologic procedures	3	15	10	2
Minor gynecologic procedures	24	14	19	27
Major genitourinary procedures	7	2	4	1
Minor genitourinary procedures	4	...	1	7
Major orthopedic procedures	11	12	7	7
Minor orthopedic procedures	1	1	3	2
Eye surgery	3	1	1	...
Head and neck surgery	7	6	2	5
Intra-abdominal procedures	...	...	3	2
Dental surgery	...	...	...	2
Total	100	100	100	100

and 50 to 100 mg. of secobarbital (seconal®) sodium. The latter was administered orally.

A 2.5 per cent solution of thiopental was used for induction in all patients. The induction dose ranged from 25 to 250 mg. Anesthesia was maintained with 70 per cent nitrous oxide and 30 per cent oxygen, supplemented by a continuous drip of either meperidine alone or meperidine-levellorphan* mixtures of three different ratios, namely, 100:1, 100:1.5 and 100:2. For this purpose solutions of 5 per cent dextrose in water were used which contained, in 500 cc., 500 mg. of meperidine alone or in combination with the appropriate amounts of levallorphan.†

The 400 patients were divided into four equal series. Thus, 100 patients each received for supplementation meperidine alone (Series I, Control); meperidine plus levallorphan in the 100:1 ratio (Series II); meperidine plus levallorphan in the 100:1.5 ratio (Series III) and meperidine plus levallorphan in the 100:2 ratio (Series IV).

The age and sex distributions of the patients in these four series are shown in Table I, and the types of operations performed in Table II.

The numbers of patients in the four series in whom succinylcholine was used for relaxation and/or intubation were seventeen, nine, nine and six, respectively.

METHOD OF EVALUATION AND FINDINGS

Respiratory rates, pulse rates and blood pressure readings were recorded for all patients initially, at frequent intervals and at completion of surgery.

Moreover, the reactivity of the patients at the end of the operations was studied.

The average duration of surgery and the average requirements of meperidine, levallorphan and thiopental (for induction and supplementation) in the four series are listed in Table III. As is seen, the average duration of surgery was similar in the four series and the average milligram per minute requirements both of meperidine and thiopental were largest in Series IV (meperidine-levallorphan ratio 100:2). It is also obvious that the average

* Levallorphan (lorfan®) tartrate was supplied for this study by Roche Laboratories, division of Hoffmann-La Roche Inc., Nutley, New Jersey.

† The flow rate of the meperidine solution and the meperidine-levallorphan mixtures was regulated depending on depth of anesthesia.

TABLE III

DURATION OF SURGERY; TOTAL MEPERIDINE, LEVALLORPHAN AND THIOPENTAL REQUIREMENTS; AND AVERAGE MILLIGRAM PER MINUTE MEPERIDINE AND THIOPENTAL REQUIREMENTS IN FOUR SERIES OF 100 PATIENTS EACH

	Series I Meperidine Alone	Series II Meperidine + Levallorphan (100:1)	Series III Meperidine + Levallorphan (100:1.5)	Series IV Meperidine + Levallorphan (100:2)
Duration of surgery (min.)	15–305 (avg. 77.3)	17–310 (avg. 88.02)	15–410 (avg. 87.4)	10–405 (avg. 76.5)
Total meperidine requirements (mg.)	25–450 (avg. 122.35)	20–420 (avg. 141.0)	25–950 (avg. 152.45)	20–500 (avg. 144.5)
Total levallorphan requirements (mg.)	.....	0.2–4.2 (avg. 1.41)	0.37–14.2 (avg. 2.28)	0.4–10 (avg. 2.89)
Total thiopental requirements (mg.)	90–1,125 (avg. 417.75)	150–1,110 (avg. 478.6)	25–1,725 (avg. 423.5)	125–2,150 (avg. 488.6)
Average mg./min. meperidine requirements	1.58	1.61	1.75	1.89
Average mg./min. thiopental requirements	5.41	5.43	4.85	6.38

TABLE IV

INCIDENCE OF APNEA AND OF RESPIRATORY RATES BELOW 12 IN FOUR SERIES OF PATIENTS

	Patients without Succinylcholine	Patients with Apnea (%)	Patients with R.R. < 12 (%)	Total No. of Patients with Respiratory Depression (%)
Series I (meperidine alone)	83	4 (4.8)	12 (14.4)	16 (19.2)
Series II (meperidine + levallorphan, 100:1)	91	.....	4 (4.4)	4 (4.4)
Series III (meperidine + levallorphan, 100:1.5)	91	1 (1.1)	2 (2.2)	3 (3.3)
Series IV (meperidine + levallorphan, 100:2)	94	.....	2 (2.1)	2 (2.1)

milligram per minute meperidine requirements in Series I ("meperidine alone" series) and in Series II (meperidine-levallorphan ratio 100:1) were practically identical, as were the average milligram per minute thiopental requirements in these two series.

For evaluation of the effects of the four medications on respiration during surgery, the patients who had received succinylcholine were excluded. The numbers of patients in whom apnea developed or whose respiratory rate decreased to below 12 of the eighty-three, ninety-one, ninety-one and ninety-four patients thus remaining in the four series, are presented in Table IV. It can be seen that the incidence of respiratory depression (apnea and respiratory rates below 12) was 19.2 per cent in the "meperidine alone" series, and ranged from 2.1 per cent to 4.4 per cent in the three series of patients who received the meperidine-levallorphan mixtures. Thus, considerably less respiratory depression occurred when levallorphan was used in conjunction with meperidine than when meperidine was used alone. Furthermore, it is obvious that the protecting effect of levallorphan at the three ratios was of the same order of magnitude.

The Chi Square test was applied to determine the significance of the difference between the numbers of cases having respiratory rates below 12 with or without apnea on the one hand and the numbers of cases with respiratory rates above 12 on the other. Meperidine alone was compared to meperidine-levallorphan in the three ratios, as is shown in Table V.

These data show that the difference between the incidence of respiratory depression, when meperidine alone and when meperidine in conjunction with levallorphan were used for supplementation, is statistically significant.

TABLE V

COMPARISON OF NUMBER OF CASES WITH APNEA OR RESPIRATORY RATES BELOW 12 WITH NUMBER OF CASES WITH RESPIRATORY RATES ABOVE 12

	Apnea + R.R. < 12	Without Apnea R.R. > 12	Total	Per cent with Apnea + R.R. < 12
Meperidine (Series I)	16	67	83	19.2*
Meperidine + Levallorphan (Series II, III, IV)	9	267	276	3.3*
Total	25	334	359	7.0

* Probability <0.01.

TABLE VI

INCIDENCE OF DECREASE AND INCREASE OF RESPIRATORY RATES AT THE END OF SURGERY IN FOUR SERIES OF 100 PATIENTS EACH

	Series I Meperidine Alone	Series II Meperidine + Levallorphan (100:1)	Series III Meperidine + Levallorphan (100:1.5)	Series IV Meperidine + Levallorphan (100: 2)
Percentage of patients with decreased rates	62	28	26	27
Percentage of patients with increased rates	7	24	27	25

TABLE VII

POSTOPERATIVE REACTIVITY IN FOUR SERIES OF 100 PATIENTS EACH

	Series I Meperidine Alone	Series II Meperidine + Levallorphan (100:1)	Series III Meperidine + Levallorphan (100:1.5)	Series IV Meperidine + Levallorphan (100:2)
Percentage of patients responding to commands	31	10	35	13
Percentage of patients with active pharyngeal reflexes	29	40	19	53
Percentage of patients without active reflexes	40	50	46	34

Table VI shows the percentages of patients in the four series in whom the respiratory rates at the end of surgery were lower or higher than those preoperatively.

It is evident that the incidence of decrease in respiratory rate at termination of surgery was considerably higher, and the incidence of increase of these measurements significantly lower in the patients of the "meperidine alone" series, than in the three series whose patients had received the meperidine-levallorphan mixtures at the different ratios. Again, the addition of different amounts of levallorphan produced practically identical results.

The effects of anesthesia on pulse rates and blood pressure readings were inconsistent, but the deviations in all four series were insignificant. Anesthesia was satisfactory in all four series.

As appears from Table VII, listing the postoperative reactivity of the patients in the four series, the percentages of cases which responded to commands within five minutes of termination of surgery varied considerably in the series

studied. However, if the patients who responded to commands and who had active pharyngeal reflexes are grouped together, the incidence of reactivity in the four series was approximately the same, namely, 60 per cent, 50 per cent, 54 per cent and 66 per cent, respectively.

The occasional occurrence of nausea and vomiting in the postoperative period was about evenly distributed in the four series.

COMMENTS

The data presented prove conclusively that the addition of levallorphan to meperidine, used for supplementation, affords considerable protection against narcotic-induced respiratory depression and that the antagonistic effect of 1 part of levallorphan to 100 parts of meperidine is equally as great as that of 2 parts of the narcotic antagonist to 100 parts of the narcotic analgetic. The fact that the average milligram per minute requirements of both meperidine and thiopental were greatest in Series IV, whose patients had received the largest amounts of levallorphan, suggests that at the higher dose level the narcotic antagonist interferes to some extent with meperidine analgesia. For this reason, and since one should always administer the smallest dose of any agent which will produce the desired results, we recommend that a meperidine-levallorphan mixture at the 100:1 ratio be used for supplementation of nitrous oxide-oxygen-thiopental anesthesia. Also, Swerdlow [7] studied ventilation in twenty patients, each of whom had received meperidine alone and meperidine plus levellorphan in the 100:1 and 100:2 ratios, and concluded that "on all counts the 100:1 ratio is preferable." He found that the average minute volumes of the two groups of patients on the mixtures were significantly better than those of the patients on meperidine alone, but there was no significant difference between the groups of patients who had received the mixtures at the two ratios.

Similarly, Hamilton and Cullen [8,9] studied the effects of levallorphan on respiratory depression from often deliberate overdoses of meperidine, used for supplementation of nitrous oxide-oxygen anesthesia, and observed that in the majority of the thirty-four patients who had received levallorphan after meperidine, 1 mg. of levallorphan or less reversed the respiratory depression produced by each 100 mg. of meperidine.

Our results with meperidine-levallorphan mixtures presented herein and the findings with a combination of alphaprodine-levallorphan previously reported [3] are in agreement in that levallorphan was an effective antagonist against narcotic-induced respiratory depression. However, the results in these two studies were different in that the postoperative recovery of the patients who had received alphaprodine-levallorphan for supplementation was more prompt than that of the patients in whom meperidine-levallorphan mixtures were used for this purpose.

SUMMARY AND CONCLUSIONS

Four hundred surgical patients were studied, of whom 100 each received meperidine (demerol) hydrochloride alone and meperidine-levallorphan (lorfan) tartrate mixtures in ratios of 100:1, 100:1.5 and 100:2 by continuous drip for supplementation of nitrous oxide-oxygen-thiopental (pentothal) sodium anesthesia. The four series were comparable as to age and sex distribution of patients; types of operations performed; premedication administered; anesthetic management and average duration of surgery.

The average milligram per minute requirements of both meperidine and thiopental were largest in the series of patients who received the meperidine-levallorphan mixture at the 100:2 ratio. This suggests that at this dose level levallorphan interferes to some extent with meperidine analgesia.

The incidence of respiratory depression (apnea and respiratory rate under 12) was 19.2 per cent in the "meperidine alone" series and ranged from 2.1 per cent to 4.4 per cent in the three series of patients who received the meperidine-levallorphan mixtures. Since this difference is statistically significant ($p < 0.01$), it is concluded that the addition of levallorphan to meperidine affords considerable protection against narcotic-induced respiratory depression. The degree of this protection with the three ratios of the meperidine-levallorphan mixtures was of the same order of magnitude.

The incidence of decrease in respiratory rates at termination of surgery, as compared with preoperative rates, was considerably higher and that of increase of these measurements significantly lower in the "meperidine alone" series than in the three series whose patients had received the meperidine-levallorphan mixtures.

The postoperative recovery of the patients in all four series was not so prompt as that observed in a previous study in which a mixture of alphaprodine (nisentil) hydrochloride and levallorphan was used for supplementation.

The supplementation of nitrous oxide-oxygen-thiopental anesthesia with a continuous drip of premixed solutions of meperidine and levallorphan provides satisfactory anesthesia. The findings presented suggest that the 100:1 ratio of meperidine to levallorphan is the combination of choice.

Acknowledgment: The authors are grateful to Dr. Leo A. Pirk of Roche Laboratories, Division of Hoffmann-La Roche, Inc., Nutley, New Jersey, for his helpful effort in connection with this project and to Mr. A. B. Siegelaub for the statistical analysis of our data.

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Vaginal Plastic Surgery Based on a New Concept of the Anatomy of the Female Genital Tract

V. BIRTH INJURIES TO THE PERINEUM AND THEIR TREATMENT, PREVENTIVE AND ACTIVE*

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STRANGE as it may seem, the term perineum does not mean the same to the general anatomist as it does to the obstetrician and gynecologist.

To the general anatomist, the perineum represents the large musculofascial mass which occupies and fills in the pelvic outlet. It covers a large area. It extends anteroposteriorly, from the pubis to the coccyx. Laterally, it is bound by the rami of the pubis and ischium, and the ischial tuberosities. This perineum is also spoken of as the pelvic floor and the pelvic diaphragm.

However, to the obstetrician and the gynecologist, the perineum has an entirely different significance. Actually, it represents only a small segment of the anatomic perineum. It extends anteroposteriorly from the orifice of the vagina to the anus. Laterally, its boundaries are not well defined, and are really of no concern from a practical point of view. It is quite apparent, therefore, that it covers only a relatively small area, and to speak of perineal injuries as lacerations of the pelvic floor does not seem quite logical.

Another factor to be mentioned is that the interest of the obstetrician in the perineum is quite different from that of the gynecologist.

The obstetrician, from the moment the pregnant woman comes under his care, regards himself, and is looked up to by the patient, as a sort of custodian of this part of her anatomy, and he dedicates himself to the task of exerting every effort to preserve its integrity.

To the gynecologist, the perineum is no longer the architectural structure that nature provided the patient with, but is now distorted and disorganized, and to him is assigned the task of reconstruction and rehabilitation.

Neither the obstetrician nor the gynecologist is always successful in his efforts.

THE CONSTITUENT ELEMENTS OF THE PERINEUM AS RELATED TO BIRTH INJURIES AND THEIR SEQUELAE

If we were to view, from within the vagina, the perineum of a normal, healthy, undamaged young woman, we would observe that it starts from the commissure of the inferior fornix (which is the lower part of the intravaginal vestibule), as described in a previous article [*1*], and ascends almost vertically toward the orifice of the vagina.

If we remove the vaginal coat, which lines the inner wall of the perineum, there would be exposed to view the levator ani muscles and fused fascia between them. At this point consideration should be given to the anatomy of this very important structure of the pelvic floor.

The Anatomy of the Levator Ani Muscle. In its early course the levator ani muscle consists of two individual parts and is, therefore, frequently referred to in the plural as the levatores ani muscles. Each levator muscle takes its origin from the posterior surface of the pubis at some distance from the median line, that is, the symphysis pubis. There is, therefore, space between them.

* Parts I, II, III and IV appeared in the May, July and October 1957 issues, and the March 1958 issue, respectively, of *The American Journal of Surgery*.

Each individual muscle then continues downward and backward, to converge toward the rectum. The rectum leaves the pelvis through the gap between the muscles, to become the anus. The individual levator muscles become fused into one muscle behind the rectum, and the rectum rests upon it.

Each levator muscle is encased within two layers of pelvic fascia: one layer on its upper or pelvic surface, and the other on the under or perineal surface. These two layers become fused at the median border of each muscle and then extend medially to meet the fused fascia from the other side to form a bridge of fascia between the two muscles.

This bridge of fascia is deficient in the median line at three points, which permits the exit of the lower ends of three important pelvic organs, namely, the lower end of the urethra, the lower end of the vagina and the lower end of the rectum. The phrase "the lower end" has been repeated intentionally to emphasize the fact that it is only ends of these organs that have any relation to the levator ani muscle.*

With that understanding of the relationship of the levator ani muscle to the perineum, considered from the obstetric-gynecologic point of view, we may now resume the dissection of the perineum.

Next to the levator muscles and their fascia and, in front of them, is another muscle, the sphincter vaginae muscle. It is a U-shaped muscle, forms a sling around the lower end of the vagina, and serves as a constrictor of the orifice of the vagina.

In front of the sphincter vaginae muscle is a dense sturdy fascia, which, as will be noted later, is of great importance to the obstetrician as well as to the gynecologist.

However, both the sphincter vaginae and the fascia in front of it have received little attention in the obstetric-gynecologic literature.

The final layer of the perineum is, of course, the skin, but it is of less significance insofar as the actual function of the perineum is concerned.

THE FUNCTION OF THE PERINEUM IN PARTURITION

In the description of the anatomy of the female genital tract, it was stated that the lower end of the vagina is the wide, expanded part of this organ, which was designated as the intravaginal vestibule [1]. This vestibule is at right angles with the succeeding or the tubular part of the vagina. Therefore, the perineum, which constitutes the front wall of this vestibule, is also at right angles to the tubular part of the vagina.

During labor, when the presenting part, for example, the head, reaches the intravaginal vestibule (which is a space of considerable size) and uterine contractions continue, it meets with the resistance of the perineum, the powerful musculofascial barrier. We say the head is born by extention, but actually the head becomes very much extended a long time before it is born. With each uterine contraction, the head is forced to climb up against this steep incline and is forced backward on the spine, that is, it is extended by the resistance of the musculature of the perineum.

It is at this stage that the obstetrician becomes aware of the impending danger of the laceration of the perineum, and he concentrates all his skill and ingenuity to prevent such damage, although he is not always successful.

When the younger obstetrician delivers a primipara and, upon immediate examination of the perineum, flatters himself that due to his skillful maneuvering there "wasn't even a scratch," his conceit and self-deception are exceeded only by his innocence. The scratch was there but was concealed from his view for the time being because the lacerations were either submucous or subcutaneous. However, they will become manifest sooner or later, perhaps only a few weeks later, when the patient comes in for the final examination and discharge. The sagging vagina, previously discussed [1], is a distressing result of the misadventure. The fact remains that a large body cannot force its way through a relatively small aperture without leaving some damage behind.

The attempt to prevent lacerations is a commendable ambition, but a disappointing reality. In the final analysis, the only positive preventive of lacerations is delivery by cesarean section.

What can the obstetrician do at least to minimize the damage to the tissues of this part of the genital tract?

General anaesthesia, no matter how deep, does not prevent lacerations. It helps the ob-

* The rectum, resting on the fused part of the leavtor muscle is beyond the area of the perineum under consideration.

stetrician in holding back the advancing head for a while, but not infrequently he has to use all the strength he has to push the head back, not realizing at the time how much damage he may be causing to the inner contents of that structure. However, lacerations will occur in spite of his good intentions.

In the early development of modern obstetrics, an attempt was made to "iron out" the vagina by gradual stretching, manually, of the orifice of the vagina under general anesthesia, with the idea that that would provide more room for the advancing head. The futility of this method was eventually realized and the practice was gradually abandoned.

Then perineotomy came into vogue. This, unquestionably, was a great advance in obstetric surgery. Here we were supposedly dealing with a clean, incised surgical wound, so that, when properly repaired, it favored good healing. Unfortunately, that did not prevent extention of lacerations beyond the incision, and in some cases even into the anorectum.

Later lateral perineotomy was conceived. However, this has not proved a panacea, and the results in some cases are even worse, for the following reasons:

If the incision extends only through the skin, no matter how long, it does not provide much more room for the head to go through, and contralateral lacerations are not prevented. On the other hand, if the incision extends quite deep, it is bound to cut the levator ani muscle almost at right angles to the course of its fibers and, even if repaired immediately, the cut ends are liable to retract in opposite directions, resulting in a permanently damaged and asymmetric perineum.

Regarding median perineotomy, this procedure should not have been discarded as a useless and ineffective measure against extensive and destructive perineal lacerations. The fault is not in the operation as such, but in the timing of its application.

In the usual course of events the obstetrician, who is conscientiously watching the distention of the perineum controlling the advancing presenting part, by anesthesia and manual counterpressure still is hopeful that he will succeed in completing the delivery without any lacerations.

However, if the patient suddenly has a violent bearing-down pain (the skin stretched, thinned and blanched), he realizes the impending danger, promptly resorts to the application of the shears (as described in all textbooks) and cuts or, rather, crushes the tissues. Before he has a chance to do anything, the head is out and the perineum is ruptured beyond the incision.

Obviously, "prophylactic" perineotomy was performed rather late. It not only did not prevent anything but also the blanched, bloodless tissues presented a jagged, ragged wound, no better than if perineotomy had not been performed.

If median perineotomy is to be a real prophylactic against lacerations, it must be performed before the state of "impending danger," and as early as possible; then it may be expected to accomplish its purpose.

The following method of procedure is suggested:

As soon as the head approaches the perineum, it is in the widest part of the genital tract in the intravaginal vestibule. At this time perineotomy must be considered, with a definite plan as to its extent, depending upon the size of the head and the character of the bones, and also upon the condition of the patient's tissues (whether one is treating a young or an elderly primipara).

If the head is of moderate size and the bones are not too hard and are well molded, only moderate perineotomy, or what might be termed minor perineotomy, will be required. On the other hand, when dealing with a large head and hard unmolded bones, then very extensive, or major, perineotomy will be indicated.

MINOR PERINEOTOMY

With a scalpel, a median incision is made, beginning in the fourchet and continuing down through the skin for about 4 or 5 cm. All bleeding points are clamped and ligated. The skin edges are retracted, exposing the dense, glistening fascia.

The fascia is incised in line with the skin incision, and the edges are separated to expose the sphincter vaginae muscle.

At this stage the obstetrician has to decide whether or not the sphincter vaginae muscle is to be cut. While this muscle is a constrictor of the orifice, it is, however, dilatable and may yield to the gradual dilating force of the head, if properly guarded.

The vaginal wall is very elastic and, if the uterine contractions are not too violent and occur at regular intervals, the head will advance slowly and gradually, and will finally slip out smoothly without any damage.

The repair of such a wound is rather simple. Each layer of tissue is identified and sutured separately, and satisfactory healing may be confidently expected.

MAJOR PERINEOTOMY

This operation is based upon a certain anatomic element, and the principle of it is to segregate the anorectum, so that no harm will come to it no matter what happens to the perineum.

It will be recalled that lower down in the genital tract, where the rectal wall becomes separated from the vaginal wall, the rectum deviates backward and downward, while the vaginal wall takes an upward and forward direction. Thus a pyramidal-shaped space is formed, which anatomists have named the perineal body.*

There are no important structures in this space; it is filled with adipose tissue, a few stray muscle fibers and perhaps a band of fascia, and it is then covered by the skin. Advantage is taken of this space as a preventive of anorectal injury, as will be presently demonstrated.

Operative Technic. The incision starts in the fourchet, as previously described, but is longer, extending downward to the junction of the middle and lower third of the perineum exposing the fascia. All bleeding points are clamped and ligated.

The fascia is incised in line with the skin incision, and the sphincter vaginae muscle is exposed.

At this point an additional incision is made, a transverse incision through the perineal body at right angles to the primary vertical incision, producing an inverted T wound. Then, with blunt-pointed scissors, or with the finger, the space is opened up to its apex.

Again, all bleeding points are clamped and ligated. If there is any oozing, a light iodoform gauze pack will control it.

What has the additional transverse incision accomplished? (1) The rectum has been entirely segregated from the obstetric field, and no harm can come to it regardless of what happens to the perineum during the delivery. (2) The vertical wound with its quadrilateral-shaped flaps can now be opened up like the doors of a china closet, and a large enough space has been created for almost any sized head to go through.

Whether or not the sphincter vaginae and the vaginal wall should be cut must be left to the judgment of the obstetrician on the case. If the pains are not too violent and come at regular, rhythmic intervals, these tissues being elastic and dilatable, the advancing head will cause a gradual dilation of the passage and the head will eventually slip out slowly and smoothly without causing any damage. However, if forceps are to be used, especially the mid-forceps type, it would no doubt be better to apply a surgical incision instead of subjecting the tissues to unpredictable lacerations.

The repair of the perineotomy incision must be done with as much care and attention as one applies in the case of an abdominal incision. Each layer of the individual tissues must be isolated, identified and sutured separately. No "mass sutures" are to be used.

The transverse incision requires only the suture of the skin. A small rubber tissue drain, carried up to the apex of the space, will provide for the lymph drainage. It is removed in twenty-four or forty-eight hours.

COMMENTS

Major perineotomy, as described, was conceived by me many years ago, but I am rather hesitant to submit it to the obstetric profession as it might appear to be a rather major surgical procedure. However, in a recent article Cunningham and Pilkington [2] report that they have been performing complete median perineotomy as the "deliberate extension through the sphincter ani or into the rectum," preliminary to mid-forceps deliveries. This has induced me to submit my perineotomy as a simpler and safer procedure.

ADDENDUM

A recent article by Glennen [3] has had a sobering effect on me. It would seem that perineotomy, as practiced by some obstetricians, is not the simple procedure I depicted.

In this article Glennen quotes Odell and Seski [4] as maintaining that "a woman may

* Some textbooks on gynecology refer to the perineum as the perineal body, which is rather confusing.

lose approximately 253 cc. of blood from an episitotomy wound in the course of delivery."

This is an extensive loss of blood in so simple a procedure. No surgeon would observe with equanimity the loss of so much blood in making an abdominal incision.

To eliminate this excessive bleeding, Glennen has devised a special weighted speculum which, when applied against the perineotomy wound, controls the bleeding by compression. However, I believe the application of a few clamps to bleeding vessels and the use of ligatures would be a more practical method to control bleeding.

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Acute Volvulus of the Cecum

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IT is fortunate that acute volvulus of the cecum is a relatively uncommon condition, for reports in the literature indicate that it is associated with a mortality rate varying from 30 to 60 per cent. In view of the essential fact that this condition produces acute intestinal obstruction, the reason for these high mortality figures is delay, the waste of precious hours (and sometimes days) between the onset of symptoms and the arrival of the patient on the operating table. On occasions when delay has been of sufficient duration to jeopardize the patient's chances of survival, it would appear that this has been his own fault for having procrastinated in seeking medical aid. However, there is no doubt that at other times such delay has occurred, in spite of the patient having sought aid in time to avert catastrophe, due to the doctor's failure to diagnose acute intestinal obstruction, much less acute volvulus of the cecum. One hopes that this might be avoided since the patient's early symptoms are sufficiently severe to suggest to any doctor with a reasonably high index of clinical suspicion the probable necessity for surgical intervention. In most cases surgery is the patient's only hope of recovery and thus will lead the doctor to initiate steps toward this end.

Normally the attachments of the bowel to the posterior abdominal wall prevent the occurrence of volvulus. Absence of, or defects in, these attachments, usually due to arrested development, may result in a much increased mobility of certain portions of the bowel, particularly the ileocecal region and the sigmoid colon. Such a portion of the bowel, with its always elongated and lax mesentery, fulfills the conditions necessary to cause a volvulus, namely, wide mobility and a conformation giving rise to a pedicle. Torsion, when it occurs, does so usually in a anticlockwise manner, i.e., from left to right, the terminal ileum passing over the front of the cecum, representing a continuation of the normal physiological rotation of the gut observed during the development of the embryo. In the case presented herein the torsion took place in a clockwise direction, the terminal ileum passing behind the cecum; this type of torsion occurs in a minority of cases, being found only in from 10 to 20 per cent.

In volvulus, two basic components have to be considered, the torsion of the bowel and that of the mesentery. Regarding the former, any loop of bowel which has become the subject of a volvulus must be twisted at both its ends; this means that there are always two sites of intestinal obstruction, the twist at the distal end causing obstruction of the loop itself and that at the proximal end causing obstruction of the uninvolved bowel above it. This fact is more readily appreciated in volvulus of the sigmoid than in that of the cecum since in the former the two ends of the loop are intimately related, one to the other, whereas in the latter they are separated by an appreciable distance. Moreover, the degree or acuteness of the obstruction may vary at each end of the loop; if it should be complete at both these sites the production of a closed loop will result. Thus in volvulus the bowel component alone may give rise to the most dangerous type of simple, acute intestinal obstruction, for in the closed loop the gas which soon begins to form has no commensurate avenue of escape, resulting in a rapid increase in the intravisceral tension (intraluminal pressure) within the loop; if not relieved, this increased tension soon becomes great enough to cause interference with the vascular network in the bowel wall, leading eventually to "tension" gangrene and perforation.

The torsion of the mesentery derives its importance from the fact that it may be respon-

sible for direct interference with the main blood supply to the involved loop of bowel, the large vessels concerned traversing the mesentery on their way to and from this loop. While such interference may only be sufficient to give rise to a relatively minor degree of obstruction of the venous return, leading to some congestion of the loop, it can also be severe enough to cause total occlusion of the arteries as well as the veins with resulting ischemic necrosis and gangrene. Thus, in volvulus the mesenteric component has the baneful potential ability of converting a simple obstruction of the involved loop into one of the much more serious strangulating type.

The degree of torsion in relation to both the bowel and the mesentery merits consideration. The statement that a torsion of the bowel of 180 degrees will cause complete obstruction has been repeated so often in the literature that it is apparently generally accepted. Also, it is usually stated that this degree of torsion of the mesentery is insufficient to produce strangulation of its contained blood vessels but that any further increase in the torsion, especially if this has reached as much as 360 degrees, i.e., one complete turn, will most certainly do so. However, simple experimentation with a rubber tube will show that the amount of obstruction resulting from a torsion depends not so much upon its degree as upon how abrupt or gradual the torsion happens to be. The more abrupt the torsion, the tighter it is. It is easy to demonstrate that an abrupt torsion of 90 degrees will cause complete obstruction whereas a more gradual twist of even 180 degrees will fail to do so, causing only a partial obstruction. In relation to the twisting of the mesentery, I have always considered the thickness and length of this structure to be important factors governing the onset of strangulation, for the thicker and shorter the pedicle, the less the degree of torsion necessary to produce vascular interference—"half a twist, with a short, broad pedicle may do more damage to the circulation, and be more serious in its results, than half a dozen when the pedicle is long and narrow" [*10*]. Thus, it would seem that in volvulus the presence of variable factors renders invalid the acceptance of the degree of torsion alone as the yardstick whereby the amount of resultant obstruction of the bowel or strangulation of the mesenteric blood vessels can be dependably measured. Furthermore, from these considerations it is obvious that a definite relationship can never exist between the onset of strangulation and the time factor; this means that surgical intervention is called for at the earliest possible moment in the hope of anticipating strangulation or of effecting its early relief if it has already occurred.

Although the cecum by its rounded shape predisposes to volvulus, absence of fixation of this portion of the bowel alone is insufficient to permit the formation of pedicle and the free mobility which are essential for the actual production of a volvulus. Hence we find that in all cases of volvulus of the cecum the absence of fixation of the bowel extends both distally and proximally to the cecum, involving a varying amount of the ascending colon, usually the proximal one-half or two-thirds, as well as the terminal few inches of the ileum. Characteristically such a cecum is large, flabby, thin-walled and atonic and, because of the elongated mesentery, often lies prolapsed in the lesser pelvis. These characteristics have an important bearing upon the behavior of such a cecum when it becomes the subject of acute volvulus, for they permit its rapid and enormous distention. The designation "acute volvulus of the cecum," by inferring that the lesion is limited to this portion of the bowel, does not accurately or adequately describe the condition present. As a term comprehensive enough to describe the condition would be very cumbersome, we see no objection to the retention of the present brief and generally accepted designation providing its limitations are recognized.

When a volvulus occurs in this situation it does so around the ileocolic artery as an axis, and the torsion involves both the loop of bowel, constituted as previously mentioned, and its corresponding lax and elongated mesenterium. Each end of the loop is twisted but the torsion of the ascending colon is so much more obvious than that of the ileum that the latter may easily be overlooked. The reason for this lies not only in the larger caliber of the colon but also in the much sharper demarcation between the fixed and mobile portions of this part of the bowel than between the corresponding portions of the ileum. Thus the torsion of the ascending colon is relatively abrupt and, as such, is readily apparent. On the other hand, the ileum, possessing a mesentery, is not as closely bound down to the posterior abdominal wall as is the

distal portion of the ascending colon; thus its torsion is more gradual and therefore not as readily discernible, particularly when the torsion does not exceed 180 degrees. Nevertheless, proof of the presence of a torsion of the terminal ileum is readily forthcoming, as exemplified in the case reported herein, by changes in the anatomical relationships of the ileocecal valve. In this case, in which the cecum and ascending colon were seen to have rotated through 180 degrees, not only did the valve appear on the outer side of the cecum but also its normally posterior surface now lay anteriorly, a reversal made possible only by a 180 degree torsion of the terminal ileum; this also furnished proof that both distal and proximal ends of the loop had undergone the same amount of torsion. Thus acute volvulus of the cecum, in common with volvulus in general, produces simultaneously two separate and distinct intestinal obstructions, one at each end of the loop. In a case with progressive symptomatology (as opposed to one in which abatement of symptoms would indicate a spontaneous reduction of the volvulus) one can rightly conclude that the abrupt torsion of the ascending colon has resulted in a complete obstruction of this portion of the bowel. Assuming this has occurred, what of the degree of obstruction of the small bowel due to the torsion of the terminal ileum? On the one hand, it is always possible that the torsion may be sufficient to cause complete obstruction. On the other hand, as already mentioned, the more gradual torsion of the terminal ileum, although essentially of the same degree of rotation as that undergone by the ascending colon, may result in producing only a partial obstruction of the ileum. In this event there will be present a continuity between the lumen of the proximal portion of the loop and that of the small intestine above it. In consequence of such continuity, the torsion which has completely obstructed the distal end of the loop also acts in a similar capacity in relation to the small bowel; the complete obstruction which this causes will not be as acute as would be the case if it were the result of torsion of the terminal ileum. At this early stage and under these circumstances, it is of minor importance whether the ileocecal valve is competent (the ileum then emptying its contents into the obstructed cecum) or incompetent (with regurgitation of cecal contents into the ileum), as the state of the valve can only result in some degree of variation in the intestinal dynamics without affecting the basic fact that the small bowel is completely obstructed. However, this phase lasts but a short time, for the progression of the pathological changes brings about in the following manner the development of a factor which supersedes the more distal torsion of the ascending colon as the agent causing complete obstruction of the small bowel. As the cecum becomes rapidly distended with gas, the stretching of its wall necessarily involves the lips of the ileocecal valve since they form an integral part of it, rendering them tense and bringing them tightly together, thus closing the valve and preventing the passage of gas or other fecal material through it in either direction. Thus in relation to the cecum the valve has become menacingly competent (although it might have been incompetent under normal circumstances), converting the cecum and ascending colon into an expanding closed loop; in relation to the ileum, however, the valve has ceased to act as such by being transformed into an impassable and complete obstruction. Therefore, it is apparent that an acute, complete obstruction of the small intestine from one cause or another, as previously indicated, is an inevitable accompaniment of acute volvulus of the cecum, a fact which has not been given sufficient recognition. Its importance in the symptomatology and clinical diagnosis of acute volvulus of the cecum will be referred to later. These considerations lead me to the opinion that the dilatation of the small bowel which always occurs in a case of acute volvulus of the cecum is not the result of gaseous contents escaping from the cecum through an incompetent ileocecal valve, as it is often considered to be, but represents the distention resulting from its acute obstruction.

It is of no small interest that the literature indicates more articles have been written about the diagnosis of acute volvulus of the cecum by roentgenological means than have been devoted to the possibility of achieving the diagnosis by a consideration of the clinical aspects. It would be wrong to deny the usefulness of roentgen studies in the diagnosis of this condition but I cannot share the attitude of clinical impotence implied by certain statements in the literature. Browne and MacHardy [1], for example, consider that there are no diagnostic criteria which render a clin-

ical diagnosis feasible; Donhauser and Atwill [6] write that "The signs and symptoms of a volvulus of the cecum are as a rule bizarre," while Weiner [11] is responsible for the statement that "The lesion presents a bizarre symptomatology and there is no definite pattern or signs which can aid in arriving at a clinical preoperative diagnosis." I believe that there is nothing "bizarre" about the symptomatology for it is that of acute intestinal obstruction; relative to this Weiner describes his patient as complaining of intermittent, cramping abdominal pains, nausea, vomiting and constipation which, after all, constitute the tetrad of cardinal symptoms of this condition. Furthermore, I believe that certain rapidly developing signs will be found which can definitely aid one in arriving at what can be described at least as a strongly presumptive preoperative clinical diagnosis of acute volvulus of the cecum. These will be mentioned later at some length.

The following recent case of acute volvulus of the cecum lends itself well as a basis for the discussion of various important and interesting clinical aspects of this serious condition.

CASE REPORT

L. B., a fifty-nine year old white woman, was admitted to the Santa Barbara Cottage Hospital at 7:00 A.M. on January 27, 1956, complaining of severe abdominal pain, nausea, vomiting and inability to pass either feces or flatus.

The patient had awakened about 3:00 A.M. with a pain in the abdomen localized in the lower right side. Within a few minutes this pain had become of the utmost severity and seemed to be all over the abdomen, coming on suddenly in cramps which quickly reached a climax and as quickly subsided, only to start again "amost as soon as the last cramp had passed off." Within an hour of the start of the pains the patient became very nauseated and began to vomit at frequent intervals. The vomitus at first looked like soup she had eaten for supper, but after a while she felt so ill that whatever changes may have taken place in its appearance went unheeded; however she stated that the vomitus developed a bitter taste. She attempted to take an enema but succeeded in introducing only 1 or 2 ounces of fluid and no result was obtained. She was seen by Dr. William Bruckner about two and a half hours after the onset of her symptoms. He diagnosed her case as one of acute intestinal obstruction; at that time he noted a mild degree of generalized abdominal distention. He sent her into the hospital with orders on arrival for the insertion of a Levin tube with suction, the institution of intravenous therapy and a flat x-ray film of the abdomen.

Twenty years previously the patient had undergone hysterectomy for fibroids which had been giving rise to attacks of profuse hemorrhage. For many years constipation had been the bane of her existence, increasing to such an extent that for the past few years a daily enema had been the only answer to her problem in spite of medical advice and care on more than one occasion. In 1952 and again the next year she had brief attacks of very severe constipation accompanied by vomiting, but pain was insignificant on both these occasions; on the second occasion a barium enema was given, revealing a colon of large diameter and a very dilated and elongated cecum extending downward into the lesser pelvis. (Fig. 1.) She was hospitalized a year before for a "heart attack" diagnosed as coronary thrombosis, but after two months had apparently recovered fully and had had no similar symptoms up to the time of her present admission to the hospital.

When seen in the hospital some six hours after her illness began, the patient (a well developed and well nourished white woman of about her stated age) was complaining of abdominal pain, was restless and looked acutely ill. A Levin tube was in place attached to a Bell suction apparatus, its attached bottle containing about 150 cc. of rather dark-colored fluid; a solution of 5 per cent glucose in saline was running into a vein. Pulse, temperature and blood pressure were all within normal limits. Eyes reacted normally to light and accommodation; the tongue was slightly furred but there was no odor to the breath. No swellings were seen or palpable in the neck. The lung sounds were normal throughout; there was no enlargement of the heart, rhythm was regular and sounds were normal. On inspection the abdomen was seen to be markedly distended but in a strikingly asymmetrical manner; the right lower quadrant bulged anteriorly, well above the general level of the abdominal wall, to form a circumscribed swelling from a little above the level of the umbilicus to the pubis below and slightly beyond the midline of the hypogastrium. The general outline of this swelling was oval with the long axis running in a downward and medial direction. No peristaltic movements were visible; a lower midline scar was present. On palpation the abdomen was tense throughout but somewhat more so over the swelling in the right lower quadrant; tenderness was minimal although greater over this region. The swelling was not moveable and its edges were ill-defined; no peristaltic movements were palpable. On percussion a tympanitic note was obtained throughout the abdomen, being of a somewhat higher pitch over the bulging right lower quadrant than elsewhere.

FIG. 1. Film of barium enema taken in 1953 showing a dilated, elongated cecum extending well down into the lesser pelvis.

FIG. 2. Flat x-ray of abdomen showing marked saccular dilatation of the cecum and lower ascending colon. No gas in colon distal to this point. Loops of small bowel are moderately distended, some of which are seen to the right of the distended cecum.

On auscultation the peristaltic sounds were noted as being definitely increased and occasional rushes and tinkles were heard. Digital rectal examination revealed a marked downward bulging of the peritoneal cul-de-sac, giving the impression of a tense mass filling the lesser pelvis.

The blood count per cu. mm. was 4,980,000 red blood cells, 14,000 leukocytes with 14 stabs, 70 segmented forms, 10 lymphocytes, 1 eosinophil and 1 basophil; the hemoglobin was 13.6 gm. per cent. Urinalysis was normal except for the presence of a few white cells per high power field.

The provisional clinical diagnosis was acute intestinal obstruction due to acute volvulus of the cecum; this will be the subject of later comment.

A flat film taken of the abdomen (Fig. 2) was reported on by Dr. Russell Gates as follows: anteroposterior and left lateral decubitus films showed a marked saccular distention of the cecum and lower ascending colon with the mass of the cecum near the midline in the pelvis; there was considerable distention of loops of the small intestine in the right side of the abdomen, presumably those of ileum. These findings were interpreted as being those of volvulus of the cecum.

The patient was taken to surgery about eight hours after the onset of her symptoms.

At operation the old lower midline scar was excised, the wound deepened and the peritoneal cavity carefully opened. The bluish wall of a grossly dilated portion of bowel presented. On further investigation this proved to be the cecum and proximal portion of the ascending colon, tensely distended and extending from near the lower edge of the liver above, down to the rectovesical pouch below and occupying most of the lesser pelvis. A fair estimate of its measurements would be some 25 to 30 cm. in length and 12 to 15 cm. in width, thus approximating a football in size. On the anterior surface could be recognized a grossly widened taenia longitudinalis and in two places the serosal coat had split for a length of about 7 cm. To have attempted to deliver this huge thin-walled sac into the wound, impacted as it was in the lesser pelvis, might easily have resulted in its rupture. It was decompressed by the introduction of a No. 16 needle through its anterior wall, the escape of gas through the needle rendering it much less tense and enabling it to be delivered safely through the wound. The needle hole was closed with a Z-suture of No. 00 chromic catgut. Up to this point none of the other abdominal contents had been seen. With the release of the cecum from its impacted position in the lesser pelvis, the true picture became immediately obvious. The terminal ileum, dilated but not to a marked degree, was seen entering the huge cecum on the lateral side due to a 180 degree clockwise torsion (from

right to left in front) in the longitudinal axis of the ascending colon just above its mid-point. The terminal few inches of the ileum lay behind the cecum, and the posterior surface of the ileocecal valve presented anteriorly. There was no change in color of the terminal ileum indicative of interference with its blood supply. The torsion was readily untwisted and with this maneuver permitting the escape of gas into the more distal portion of the colon, the cecum became flaccid and quickly regained its normal color and the ileum its normal caliber. It was noted that the site of torsion of the ascending colon seemed rather attenuated and the torsion could be readily reproduced; because of this it was considered that simply to replace the large and flabby cecum would be to invite a recurrence of the volvulus. Cecopexy was therefore performed, using two rows of interrupted sutures of No. 00 chromic catgut to anchor the lateral wall of the cecum to the parietal peritoneum of the right paracolic gutter. As an added precaution against a recurrence, the attenuated mid-portion of the ascending colon was buttressed by suturing to it the mesentery of the terminal 3 inches of ileum, close to the bowel. The two tears in the cecal serosa were each closed with a running suture of No. 00 chromic catgut. Six hundred thousand units of penicillin and 1 gm. of dihydrostreptomycin in 20 cc. of saline were poured over the cecum and adjacent bowel, and the abdominal wound was closed in layers without drainage.

The patient did very well for forty-eight hours at the end of which she began to complain of abdominal discomfort; an ileus developed with symmetrical distention and absent peristaltic sounds. This was treated by intubation with a Cantor tube, the administration of prostigmin® and the parenteral maintenance of electrolytic balance. The tube was left in place six days by which time the distention had subsided and peristaltic sounds had returned to normal; a small amount of a thin barium mixture injected down the tube was found to have reached the splenic flexure of the colon a few hours afterward. Shortly after the removal of the tube the patient began to have natural bowel movements and she was discharged from the hospital on February 9th, her wound having healed *per primam artem*.

When the patient was seen several months later it was learned that not long after her discharge from the hospital she began to be troubled with intermittent attacks of abdominal distention associated with some pain, constipation and occasional vomiting. Gastrointestinal x-rays taken in November, 1956, were reported as negative. Finally, the patient was operated upon as an emergency for acute intestinal obstruction in February, 1957, at another hospital. The cause of obstruction was found to be multiple adhesions among the coils of the lower ileum; at this operation the cecum was seen to be lying free except for an attachment at one point to the parietal peritoneum of the right paracolic gutter. This subsequent history and findings will be the subject of later comment.

COMMENTS

Age and Sex Incidence. While we know that most of the reported cases of acute volvulus of the cecum have occurred in men between the ages of twenty and forty, perhaps it is of equal, if not of more, importance for us to bear in mind that a patient of either sex, in spite of being under twenty or over forty years of age, may still be the victim of this condition. In other words, we should not fall into the temptation of ruling out the possibility of the occurrence of this serious condition simply on grounds of age and sex.

Past History. It has been repeatedly noted by writers on the subject of acute volvulus of the cecum that it is not unusual to find that persons in whom this condition develops give a history of having undergone one or more abdominal operations. There is a definite reason for this. A person with a large, flabby, mobile and prolapsed cecum (the prerequisites for volvulus of this portion of the bowel) often complains of pain of varying degree in the right lower quadrant for which there would appear to be two possible explanations. First, this pain might be the result of such a cecum failing to perform its functions properly, on the basis that its poor muscular tone prevents the efficient propulsion of its contents upward into the more distal colon against the force of gravity as is required of it most of the time; this could permit a stasis resulting in distention from the formation of gas in abnormal quantities, leading to right-sided pain and discomfort. Second, it is possible, and indeed probable, that in some cases, especially when the pain is of a more severe type, this is due to the beginning of a volvulus which fortunately becomes untwisted instead of progressing so that the pain passes off and the attack subsides. It is not surprising, therefore, to find that most of these patients have had their "chronic appendix" removed at one time or another without symptomatic relief (the gallbladder has also been surgically assaulted in such persons). Furthermore, such a cecum can give rise to what may be considered a right-sided ad-

nexal mass and so furnish the impetus at least for laparotomy, terminating perhaps in a salpingo-oophorectomy or an even more extensive pelvic procedure. However, in the present case the patient had undergone only one abdominal operation and this was not for abdominal pain of doubtful origin but for bleeding uterine fibroids, hysterectomy and appendectomy having been performed on that occasion. In view of these considerations, whenever laparotomy reveals the presence of a cecum which is large, flabby, mobile and prolapsed, much can be said for its fixation by a well performed cecopexy or by the use of a peritoneal flap, such as devised by Dixon [5], as a prophylactic measure against the future occurrence of a volvulus and in the further hope that "taking up the slack" may lead to improvement in cecal function with resulting diminution of symptoms. Because of the patient's previous hysterectomy it was interesting to note at operation the complete absence of any adhesions involving the pelvic floor, omentum and large or small gut, the cecum being entirely free and the volvulus of the primary type. Secondary volvulus, in which the pedicle is produced artificially by some extrinsic factor such as a band or adhesion, appears to occur rarely insofar as the cecum is concerned.

A history of constipation extending over a period of years is always to be elicited, and the present case proved to be no exception to this general rule. In fact this symptom had been of the utmost severity in the case described herein.

Clinical Diagnosis. A prominent feature of articles written on the subject of acute volvulus of the cecum is the repetition of the statement to the effect that in this condition the symptomatology provides insufficient criteria by which the clinical diagnosis can be established. I believe that this is not the case and in support of my contention offer the following consideration of some of the clinical aspects of this condition and the bearing they have upon its diagnosis.

It is important to realize that to speak of a case as one of acute volvulus of the cecum is to involve not one, but two, diagnoses. The first and essential one is that of the acute obstruction produced by the volvulus. An acute obstruction of the intestine may be caused by one of many agents but once it has occurred, whatever the cause, it gives rise to its characteristic symptoms. These are well known and are basically the same no matter what the obstructing agent may be; most important, it is these symptoms which indicate the necessity for surgical intervention which, except in a minority of cases, alone can offer the patient hope of recovery. In acute intestinal obstruction, therefore, the symptoms upon the recognition of which successful treatment depends are those of the effects produced by the obstructing agent and not those of the agent *per se*. Thus the diagnosis of the obstructing agent is not essential for the institution of the proper surgical treatment. Actually, in most cases of acute intestinal obstruction the nature of the obstructing agent is not definitely known before operation, no matter how nearly correct conjecture on the subject may eventually prove to be, although it is not unusual to be more positive regarding its location. Nevertheless, no surgeon responsible for the management of one of these patients would allow whatever uncertainties he might have on these points to interfere with his decision to open the abdomen if he believed that the symptomatology warranted operative intervention.

The second diagnosis is that of the acute volvulus of the cecum itself although, as just pointed out, this diagnosis is no more essential than that of any other obstructing agent for the institution of the proper surgical treatment of the acute intestinal obstruction to which it has given rise. To make this second diagnosis is worth while, for it has the advantage of arming the surgeon with a foreknowledge that will be of help in directing his surgical approach, apart from the satisfaction it brings of diagnostic achievement. Moreover, I believe that despite the opinions to the contrary which prevail in the literature, a careful evaluation of the symptomatology should lead to this preoperative diagnosis being at least strongly suspected, if not actually made, on clinical grounds.

Ordinarily the diagnosis of acute intestinal obstruction is not difficult because of the characteristic symptomatology to which this condition gives rise. Its four cardinal symptoms consist of intestinal colic, nausea, vomiting and absolute constipation, all of which were noted in marked degree in the case reported herein. When an acute obstruction of the small bowel is present, any of these symptoms is so rarely absent that one wonders how often an "atypical" case is so designated as the result of

careless observation or faulty record; on the other hand, in cases of acute obstruction of the large bowel it is generally found that not only are the symptoms less severe but also nausea and vomiting in particular may be minimal or even absent. Its early signs are: a small degree of abdominal distention (with a fairly uniform percussion note) and increased peristaltic sounds, all becoming more pronounced with the passage of time if the obstruction is not relieved. Palpation, which at first will probably no more than confirm the presence of some distention, becomes increasingly important as time goes by because of the findings it alone can elicit, the correct interpretation of which may prove to be of invaluable help in diagnosis. For example, by increasing the intravisceral tension in an already distended loop of bowel, palpation may cause localized pain and so indicate the presence of such a loop before the loop itself becomes distended enough to be felt; later, and more particularly when a strangulating lesion is present, it may detect the presence of a distended loop where none was palpable a few hours earlier. It may also, by eliciting tenderness and rigidity, reveal the presence of peritoneal irritation caused by infected transudate from a strangulated loop of bowel and thus may actually provide the first indication that strangulation has occurred, since detection of the loop itself may be equivocal. Such, in brief, is the symptomatology of acute intestinal obstruction. However, the clues which can lead us to diagnose acute volvulus of the cecum as the cause of an intestinal obstruction are to be found in the modifications which, by virtue of its nature and location, the volvulus produces in the aforementioned outlined clinical picture. These modifications and the factors responsible for them will now be given consideration.

The outstanding general characteristics of the symptoms of the acute obstruction produced by an acute volvulus of the cecum are their sudden onset and great severity. As pointed out previously, an essential part of the pathological picture of acute volvulus of the cecum is a concomitant acute, complete obstruction of the small bowel; the importance of recognizing this fact is that it accounts for the basic severity of the symptoms. However, certain additional factors play their part in augmenting this severity. It is well known that if the abdomen is opened under local anesthesia the bowel may not only be handled gently but also on the contrary may be subjected to the most severe trauma without the patient feeling even discomfort; on the other hand, should manipulation result in any drag upon, or torsion of, the mesentery or mesocolon, the patient will immediately complain of a severe, nauseating type of pain. This is what happens in acute volvulus of the cecum for the torsion involves the lax, elongated mesentery as well as the bowel itself and helps to account for both the sudden onset and the severity of the symptoms. A further cause of acute abdominal pain is the rapid distention of a hollow muscular viscus such as occurs in the large, thin-walled cecum when it becomes the subject of an acute volvulus. Thus in a case of acute volvulus of the cecum the acute obstruction of the small intestine, which is an essential part of the pathology, plus the additional factors mentioned previously readily account for the marked severity of the patient's symptoms. However, we must remember that the symptoms of acute intestinal obstruction due to other obstructing agents, particularly those located in the small intestine, are also severe. Since symptoms are subjective, relative severity may be difficult, if not impossible, to evaluate for the symptomatic reaction to acute disease may vary within wide limits in individuals. Thus we must face the fact that in acute volvulus of the cecum the symptoms of acute intestinal obstruction to which it has given rise are not modified sufficiently to enable us to differentiate them with any degree of certainty from those of acute obstruction caused by other agents.

However, a consideration of signs is a very different matter, for here we are dealing with objective evidence which can be observed and evaluated; hence it is among these that we must look for the modifications which provide the clues pointing to the diagnosis of acute volvulus of the cecum. In this condition there is one sign which is modified early in the course of the disease to a striking extent, making it more likely than any other to furnish the main clue for the diagnosis. This is the abdominal distention exhibiting certain features (all of which were present in the case reported) which, if carefully observed, render it unlikely to be confused with the presence of any other condition with the possible exception of acute volvulus of the sigmoid loop. These features

are three in number. The first is its marked degree; this is due to the fact that the distention involves the small bowel as well as the cecum and ascending colon proximal to the site of torsion, the latter reaching huge proportions. The second is the rapid development of the distention within a few hours of the onset of symptoms, well exemplified in the present case; when the patient was first seen some two hours after her attack began, only a minimal distention was noted while another four hours later the distention had increased enormously. The third feature of the distention is that it gives rise to a striking abdominal asymmetry; this is due, of course, to the enormous distention of the cecum and ascending colon causing a circumscribed swelling which results in the bulging forward of some portion of the abdominal wall, the asymmetrical pattern depending upon the position of the cecum. In the case reported herein it was observed in the right lower quadrant extending from a little above the level of the umbilicus to the pubis below and to slightly beyond the midline of the hypogastrium. The presence of distention having these characteristics at once eliminates acute obstruction of the small intestine as its sole cause, for in that condition, severe though the symptoms are, the amount of distention which occurs in the first few hours is usually relatively minor in degree and does not give rise to any abdominal asymmetry. As a further and important differential point, in cases of acute obstruction of the large bowel, other than those due to volvulus, neither the degree of distention nor the rapidity with which it develops are as marked as when the cause of obstruction is an acute volvulus of the cecum, for the following reason: in these cases the cecum is usually normal in size and position, and possesses normal muscular tone, features which restrict the degree and rapidity of its distention. In fact, actual hypertrophy of its wall may be present, further limiting distention if the acute phase was preceded by a period of partial obstruction as sometimes happens. In contrast, the cecum which has become the seat of an acute volvulus is always large, thin-walled and atonic, characteristics which permit rapid and enormous distention. We know that the cecum will always distend to a greater degree than any other portion of the colon proximal to the site of obstruction; however, for it to distend enough to cause the appearance of a circumscribed abdominal swelling in the absence of a volvulus will more likely take days rather than hours. Indeed, in such cases the increased intravisceral tension in the cecum may become great enough to result in "tension" gangrene, yet its distention may be insufficient to result in the appearance of such a swelling. In view of these considerations I believe that gross and asymmetrical distention of the abdomen occurring within a few hours of the onset of severe symptoms of acute intestinal obstruction points unequivocally, first, to the large bowel as the site of obstruction and, second, to the obstructing agent being an acute volvulus of the cecum or of the sigmoid loop for no other condition is likely to give rise to this particular combination of symptoms and signs. In considering the differential diagnosis between these two conditions there are three important points to be kept in mind: (1) In acute volvulus of the cecum the swelling produced by the grossly distended cecum will always be circumscribed in outline whereas that resulting from a ballooned sigmoid loop is more diffuse in type, usually occupying the entire left side of the abdomen and not infrequently extending over the midline to encroach upon the right side. (2) Because of the length of the sigmoid loop and its extensive mobility, the over-all distention of the abdomen is usually greater when this portion of the large bowel is the subject of an acute volvulus than when the cecum is similarly affected. (3) In acute volvulus the ballooned cecum may be found in different positions in the abdominal cavity depending probably more upon the line of the axis in which the torsion occurs than upon the degree of torsion itself. Thus if the axis is more or less parallel to the longitudinal axis of the ascending colon, as it was in the case herein reported, there will be only a relatively small displacement of the cecum to the left; should this axis instead be parallel to the transverse axis of this portion of the large bowel, the ballooned cecum will be found in the left hypochondrium. Obliquity of the axis of torsion will result in intermediate positions of the cecum along an arc passing cephalad and to the left from the right lower quadrant to the left hypochondrium. Mention must not be omitted, however, of the fact that the presence of the cecum in the left hypochondrium may also be the result of its participation in a complete

primary volvulus, that is, one in which the torsion occurs around the superior mesenteric artery as the axis and which involves the small as well as the large gut.

Moreover, this distention brings in its train modifications of other signs. For example, the percussion note is no longer of uniform pitch but is definitely higher over the circumscribed swelling produced by the distended large bowel than elsewhere over the abdomen. Furthermore, palpation now can not only confirm the presence of the circumscribed swelling but also cause pain by augmenting the already increased intravisceral tension within the bowel producing the swelling, so that tenderness is elicited in an area where it was previously absent.

Digital rectal examination, always a "must" in the "acute abdomen," may provide positive or negative information, either of which may prove to be of diagnostic help. If the caput of the cecum is in the lesser pelvis, its tense, rounded border may be easily felt pushing the peritoneal cul-de-sac before it, as in the case reported herein; this offers a ready explanation of the failure of the patient's rectum to hold more than a few ounces of the enema she attempted to administer (and this in a patient who through long experience had become an expert in this form of self-therapy). On the other hand, if the cecum is not in the pelvis, digital rectal examination is not likely to divulge the presence of any abnormality; this will also usually pertain to volvulus of the sigmoid as the involved loop of large bowel is generally intra-abdominal and not intrapelvic. The giving of an enema to discover how much the lower bowel will hold or how much of the fluid will be returned, etc., may provide useful information, but in the case reported herein this procedure was not favorably considered because of the patient's distressed condition and in view of the indications already present that the mass felt rectally was cecal in origin.

At this juncture it would be well to consider the case reported herein in the light of the previous discussion of some of the clinical aspects concerning acute volvulus of the cecum.

This patient had experienced a sudden onset of symptoms of great severity—intestinal colic, nausea, vomiting and the inability to pass feces or flatus, i.e., absolute constipation—constituting those typical of acute obstruction of the small intestine. The questions which arose, as they must in every such case, were: what part of the intestinal tract is obstructed and what is the probable nature of the obstructing agent? The patient had undergone abdominal hysterectomy; this history provided the possibility of an adhesion or band in the pelvis obstructing the small bowel by kinking or pressure. However, when the patient was examined some six hours after the onset of symptoms there were apparent reasons why this possibility alone could not account for the findings. First, the degree of distention was much greater than that which might reasonably be expected only six hours after the onset of acute obstruction of the small bowel; second, had such a marked degree of distention resulted from acute obstruction of this portion of the bowel only (omitting any consideration of the time factor) it would certainly have been associated with a readily discernible "ladder" pattern of the abdominal wall, of which there was not even a suggestion; third, the distended abdomen was rendered asymmetrical by a circumscribed swelling filling the right lower quadrant and extending a little across the midline. This swelling was tympanitic on percussion, on the one hand eliminating the possibility of the presence of a tumor such as an ovarian cyst (with a twisted pedicle) and on the other indicating the cause of the swelling was an enormously distended portion of bowel. The next question was what portion of the intestine could possibly distend to such an enormous extent? The answer could only be either the cecum or the sigmoid colon, but the swelling was cecal in position and circumscribed. Most important, the left side was not distended above the general level of the abdominal wall as one would have expected if this swelling had been caused by a portion of an enormously distended sigmoid loop, the subject of an acute volvulus. On rectal examination the finger immediately encountered the tense, bulging lower end of this swelling which was filling the lesser pelvis. There seemed no reasonable doubt that the swelling was a grossly distended cecum; since the distention ceased so abruptly above, at about the level of the umbilicus, it was felt that the site of obstruction was in the ascending colon. Furthermore, the acute onset and marked severity of the symptoms considered in conjunction with the rapid and tremendous distention of the cecum favored an acute volvulus as the cause of the obstruction. Thus

what proved to be the correct preoperative clinical diagnosis of acute intestinal obstruction due to acute volvulus of the cecum was arrived at by careful evaluation of the symptomatology alone.

It is realized that not all cases of acute volvulus of the cecum may be so apparently easy to diagnose as this one, particularly if a relatively long period has elapsed between the onset of symptoms and the first examination of the patient. In such a case the advantage of being able to observe the appearance of early signs and symptoms with their crucial diagnostic significance is denied the examining surgeon; instead, he finds himself confronted by a clinical picture which may have become somewhat confused by later symptomatological developments, thus presenting a problem the solution of which is likely to call for an additional measure of diagnostic acumen. However, a perusal of case reports in the recent literature leads me to believe that in not a few instances had due consideration been given to the symptomatology as described, the diagnosis could have been made or at least strongly suspected on clinical grounds alone. Furthermore, I found that one feature common to nearly all cases was the dependence of diagnosis upon roentgenological means to the exclusion of any endeavor to establish diagnosis on the available clinical evidence. Perhaps at times we tend to forget we are fortunate enough to have been endowed with certain faculties by the use of which alone we are still able to solve at least some problems in diagnosis, not excepting that of acute volvulus of the cecum, and that it is worth our while to preserve their function by exercising them diligently and adequately lest they become impaired by the atrophy of disuse.

Roengtenological Diagnosis. Roengtenological studies have come to play a prominent part in the diagnosis of acute volvulus of the cecum especially since McGraw, Kremen and Rigler [*8*] in 1948 emphasized the help which may be obtained from a plain x-ray film of the abdomen in determining the presence of this condition. These authors concluded from their studies that the appearance of certain features on such a film point to the diagnosis of volvulus of the cecum. Although not all of them were present on the plain film taken in the case reported herein (Fig. 2), those which were proved sufficient to leave little doubt as to their significance. There was the enormously distended cecum, not dislocated very much from its normal position yet displaced sufficiently to the left to result in the abnormality of the appearance of loops of small bowel on its right side. The gas pattern of obstruction of the small intestine was plainly visible, the loops of bowel showing a moderate amount of dilatation. Neither the ileocecal valve nor the mucosal folds at the point of torsion of the ascending colon could be considered outlined satisfactorily by the gas pattern of the terminal ileum or cecum.

Some authors have stressed the barium enema as a procedure which will provide better evidence on which to base the roentgen diagnosis of volvulus of the cecum than that afforded by the plain film of the abdomen. In regard to this matter it is of interest that McGraw and his co-workers [*8*] expressed the opinion that "the criteria for the diagnosis of volvulus of the cecum are present in the simple film of the abdomen and that the barium enema is not an absolutely necessary diagnostic procedure although it may be very helpful to confirm positively the suspected diagnosis."

In the present case, the findings on the plain film provided sufficient confirmation of the clinical diagnosis to make us decide that to submit this acutely ill and much distressed patient to additional roentgen study was neither necessary nor justifiable. Indeed, because of the tensely distended lower portion of the cecum filling the lesser pelvis with resulting compression of the rectum against the sacrum, it is doubtful whether any barium mixture at all would have been able to find its way into the colon.

Treatment. The treatment of acute volvulus of the cecum is essentially surgical. Laparotomy must be undertaken with as little delay as possible, for since an acute intestinal obstruction is present the longer the time lapse from the onset of symptoms, the less chance there will be of saving the patient's life (no matter how appropriate and well performed the operative procedure may be); supportive measures to combat the physiological upset in body fluids and electrolytes and the possible toxicity occasioned by this condition are a *sine qua non.*

In the main, treatment has two objectives, the first being the untwisting of the volvulus to relieve the acute intestinal obstruction as well as any vascular interference for which it

has been responsible; the second, to deal with the involved bowel (whatever procedure employed to do this being governed by such factors as the viability of the bowel and the general condition of the patient).

A lower midline or right paramedian incision or a transverse incision just below the level of the umbilicus are all acceptable and any one of them should prove satisfactory. In the case presented herein, the patient already had a lower midline scar which was excised and the wound deepened to enter the peritoneal cavity. The surgical approach permitted by this incision was excellent and in this particular case would have been quite adequate even had a different, and more radical, type of procedure been performed.

Having entered the abdomen, the first step to be considered is the reduction of the volvulus in order to relieve the obstruction of the bowel and any strangulation which might have occurred. However, the cecum is generally huge in size, tensely distended, its wall has become very thin and it may be fixed in position as it was in the case presented in which the caput was impacted in the lesser pelvis. To accomplish satisfactorily the untwisting of such a volvulus almost certainly means that the cecum must first be delivered through the wound on to the abdominal wall; to attempt this maneuver without a preliminary decompression by means of a large needle or trocar and cannula is to invite disaster in the form of rupture of the distended bowel. The presence of one or more tears in the serosal coat of the cecum, caused by its great distention, should act as an additional warning to the surgeon of the possibility of this catastrophe which, should it occur, will be followed almost inevitably by death.

Once the torsion has been untwisted the involved bowel must be examined, for upon the evaluation of its condition will depend the choice of further treatment, if any. Should the bowel be gangrenous or its viability questionable, there is general agreement that resection is mandatory. However, it must be decided whether to perform primary ileocolostomy or to exteriorize the cut ends of the colon and ileum and thus leave the continuity of the bowel for later restoration. The chief factor influencing this decision must always be the patient's general condition, with the priviso that the worse the condition, the better the latter course.

On the other hand, if the bowel is viable, nothing more actually need be done; the relief of the acute intestinal obstruction by the untwisting of the volvulus has accomplished the main object for which emergency surgery was performed, i.e., the saving of the patient's life. However, by simply returning the bowel to its *status quo ante* the surgeon fails to take into account that, by doing so, the possibility of a recurrence of the volvulus must remain. Thus it is believed that treatment should include some further procedure aimed at preventing this. In contrast to the treatment of gangrenous bowel (which permits no argument and can be stated in a few words) the question of what to do with a viable bowel in the hope of preventing recurrence of the volvulus has given rise to lengthy discussions, because of differing opinions regarding the relative merits of the various procedures which can be used for this purpose. At present the scales appear to be weighted in favor of conservative rather than radical measures. Briefly, conservative treatment aimed at prevention of recurrence consists of cecopexy and cecostomy or appendicostomy. The more radical approach to the solution of the problem consists of resection of most or all of the right side of the colon with primary ileocolostomy.

Cecopexy commends itself as a fixation procedure in that a relatively large area of the cecal wall can be sutured to the parietal peritoneum of the right paracolic gutter, thus providing for the formation of a broad, firm adhesion which should result in a permanent fixation of the viscus. The unsatisfactory result of this operation in the case presented herein (the cecum was found a year later attached to the parietal peritoneum at only a single point) was a great disappointment as the cecopexy was performed in a painstaking and thorough manner. Evidently all the sutures, with one exception, had either cut through the cecal wall or had become loosened before adhesions had time to form. A possible cause leading to such a result could have been the distention of the cecum which occurred as part of the postoperative adynamic ileus, the stretching of the wall causing tugging on the sutures. One wonders if the result would have been different if the ileus had not occurred and, since it did, if cecostomy would have resulted in a better fixation than cecopexy. In any event this experience with cecopexy in acute volvulus of the cecum leads me to believe that in the future I

would not choose this procedure as a method of preventing recurrence. Nevertheless, I believe that the cecopexy should be exonerated from any blame in the development of the adhesions among the coils of lower ileum found at operation a year later. The fact that these developed is of interest, since none did following the previous hysterectomy; at the time of cecopexy only the terminal few inches of the ileum were handled and even then only to a limited extent, so that trauma can be dismissed as an etiological factor in the development of the adhesions. Possibly the ileus was of sufficient severity to give rise to the formation of peritoneal transudate which later became organized into fibrous tissue among loops of lower ileum, resulting in the adhesions found.

Judging from the literature, cecostomy has been, and still is, performed more frequently in cases of acute volvulus of the cecum than any other operative procedure. Its proponents not only believe that it produces a satisfactory fixation of the cecum but also stress the importance of the role it plays as the most certain means of decompressing this viscus. By so doing continuously during the postoperative period it encourages the formation of adhesions between the cecum and peritoneum of the anterior abdominal wall by preventing any undue distention of the cecum likely to put strain on the fixation sutures through stretching of its wall. Furthermore, since a tube or catheter type of cecostomy is all that is necessary, the temporary fistulous track is small and usually closes spontaneously after the withdrawal of the tube or catheter. Since this takes some time, the operation often entails a hospitalization of greater length than the other procedures, conservative or radical, which can be used in its stead; this fact is stressed as a disadvantage of the operation by its critics. The immediate results of cecostomy, however, have proved to be satisfactory in many cases. Hence there is not much likelihood of general agreement with McGraw, Kremen and Rigler [*8*] who state that cecostomy is followed almost uniformly by death, although they do not mention any personal experiences with this operation in support of their contention. Reports in the literature both before [*1,5*] and since [*2–4,7*] the publication of their paper in 1948 provide ample proof of the fallacy of their statement. The fact that adhesions form in a comparatively small area around the cecostomy opening leads one to wonder how successful this procedure is in bringing about a permanent fixation of the cecum and how its reliability in this regard compares with that of cecopexy. Unfortunately these conjectures cannot be answered with any degree of certainty because of the lack of long-term follow-up reports in the literature.

Appendicostomy has not been a common form of operative treatment in acute volvulus of the cecum. However, those who have used it as such [*5,7*] comment favorably upon it as being an effective emergency measure, its performance having been attended by satisfactory immediate results. There does not appear to be available sufficient evidence upon which to base any conclusions regarding its reliability as a fixation procedure.

From time to time recurrence of an acute volvulus of the cecum has taken place following a fixation operation and therefore consequent upon the failure of that procedure to accomplish the objective for which it was performed. Thus dissatisfaction has arisen because of the uncertainty of effecting a permanent fixation of the cecum with an operation of this type. Hence the adoption has been advocated of a definitive treatment for the prevention of recurrence that will banish totally and permanently all the danger and worry associated with this possibility. Such treatment consists essentially of resection of most or all of the right half of the colon and the restoration of intestinal continuity by immediate ileocolostomy. Melchior [*9*] makes a strong plea in favor of this procedure, supporting it with a series of five successful resections, including one case in which the cecum was gangrenous and peritonitis was present. In this series were two cases of recurrence which had been treated primarily by conservative cecal fixations, one of the patients having been operated upon by Melchior himself for acute volvulus two years previously at which time cecopexy was performed. The main objection against this procedure is that there is too high a risk associated with its performance. However, since resection is considered mandatory in a case in which the bowel is gangrenous it seems paradoxical, to say the least, to object to that procedure on these grounds when the bowel is viable, for the general condition of a patient with a gangrenous bowel is usually more serious than that of a patient whose bowel is still viable

and the risk of such an operation is correspondingly greater. Melchior, moreover, points out that his experiences show resection in acute volvulus of the cecum to be far less dangerous than usually supposed.

Such a comparatively wide experience in acute volvulus of the cecum as that of Melchior is not likely to fall to the lot of any single surgeon in America where the incidence of this condition is much lower than that found in some of the European and Asiatic countries. In fact the only article by American authors I have been able to find, reporting experiences with resection and primary anastomosis in acute volvulus of the cecum, is that of McGraw et al .[8] who describe two cases in which this was performed with success by Wangensteen and Baronofsky, respectively. In the first, in which the volvulus occurred as a complication after gastrectomy, splitting of the cecal serosa had taken place but the bowel was viable, while in the second case "changes in the bowel made it necessary to resect the cecum and ascending colon." In both cases end-to-end ileocolostomy was performed, augmented in the first case by a temporary catheter ileostomy just proximal to the anastomosis. These authors believe that if the patient's condition allows, resection of the right colon and primary aseptic ileotransverse colostomy is probably the treatment of choice. Dean [3], an advocate of cecostomy, takes the view that primary resection seems too radical a procedure for the average surgeon who, he points out, will necessarily treat the great majority of patients suffering from this acute condition. On the other hand, few will gainsay that excision of the right half of the colon is, by and large, probably the easiest of all bowel resections to perform; this is especially so when, as in acute volvulus of the cecum, the absence of malignancy precludes dealing with whatever technical difficulties might arise incident upon removal of the primary focus as well as secondarily involved lymph glands. Moreover, in acute volvulus of the cecum this procedure is further facilitated by the mobility of the cecum and most of the ascending colon, leaving only the hepatic flexure of the colon to be mobilized if ileotransverse colostomy is to be performed. Melchior even prefers not to mobilize this flexure in order to save time; he anastomoses the cut end of the ileum to that of the ascending colon above the site of torsion.

No one can fail to be impressed with the results obtained by resection and primary ileocolostomy in these reported cases of acute volvulus of the cecum. They demonstrate clearly that in this condition resection (which is the only certain way to avoid the possibility of recurrence as well as the likelihood of persistence of chronic symptoms) yields a measure of success that goes far to establish it as the treatment of choice. It is my belief that as time passes it will become more and more widely accepted and practiced as such, to the increasing exclusion of the more conservative, but less reliable, fixation procedures of cecopexy and cecostomy.

SUMMARY

1. A case is reported of acute volvulus of the cecum in which the preoperative diagnosis was made on clinical grounds.

2. While the symptomatology of acute volvulus of the cecum is basically that of the acute intestinal obstruction to which it has given rise, its recognition as the obstructing agent depends upon certain modifications which, in virtue of its nature and location, it produces in the clinical picture. These modifications are given detailed consideration.

3. The literature indicates that there is a widespread belief that it is not possible to diagnose a case of acute volvulus of the cecum on the basis of its symptomatology alone. In contrast to this belief I consider that the symptomatology of this condition, if carefully observed and evaluated, will be found to furnish sufficient criteria on which to establish the clinical diagnosis, as exemplified by the case reported.

4. It is believed that the emphasis which has come to be placed upon roentgenological studies (always so readily available) in the diagnosis of acute volvulus of the cecum appears to have had the unfortunate effect of removing in large measure the stimulus to achieve this goal rather by the exercise of one's diagnostic faculties.

5. The pathogenesis and treatment of acute volvulus of the cecum are discussed.

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Massive Hemorrhage from Diverticulosis of the Colon

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THE management of undiagnosed gross bleeding from the colon can present a perplexing problem. In recent years there has been increased interest in diverticular disease as a source of massive melena. While many other lesions of the large bowel, including carcinoma, polyps, ulcerative colitis and the common rectal lesions, frequently produce recognizable gross blood in the stool, massive hemorrhage from these sources is very unusual. It has long been recognized that bleeding occurs in diverticulitis; its occurrence is indicated in various series at from 3 to 47 per cent, most authors reporting from 10 to 30 per cent incidence [*1*]. This bleeding is usually small in amount but in a certain proportion of cases, estimated at about 4 per cent [*2*], it is of sufficient severity to require transfusions. That apparently uncomplicated diverticulosis can produce massive hemorrhage is a concept which has received attention only in the past few years. In contrast to earlier teaching portraying colonic diverticula as anatomical curiosities producing no symptoms unless a manifest inflammatory process supervenes, it can now be stated that diverticulosis is the principal source of massive hemorrhage from the large bowel [*2–4*]. While it is obvious that far advanced carcinoma can erode a sizable blood vessel, and there are a number of cases reported in which a fistulous tract from perforated diverticulitis has penetrated a large artery or vein, in these cases the diagnosis is usually fairly evident and the indicated course of treatment is reasonably clear. The real problem arises in the patient presenting profuse rectal hemorrhage with no previous history or symptoms to suggest gastrointestinal disease. This paper concerns only massive hemorrhage from apparently uncomplicated diverticulosis.

The anatomical basis for hemorrhage from diverticula has been discussed by several authors [*2,3,5–7*]. It is generally stated that the acquired "false" diverticulum is an out-pocketing of the mucosa through the muscular layers occurring most frequently in the taeniae near the mesenteric border and usually at the point where nutrient vessels penetrate the bowel wall. Thus it often lies in close proximity to sizable blood channels. Further evidence is supplied by Noer [*1*], who injected colon specimens with liquid latex and was able to demonstrate unusual vascularity in the walls of diverticula. It is obvious that hemorrhage cannot occur through the intact mucosa and that some degree of inflammation or erosion must be present. However, the area of inflammation in a bleeding diverticulum may be so localized that none of the usual symptoms of diverticulitis are produced and the typical spasm and saw-toothed appearance on x-ray examination are absent. Young and Howarth [*6*] believe that hemorrhage usually follows erosion and ulceration of a diverticulum which has become inverted. As might be expected, severe bleeding in diverticulosis occurs most often in patients exhibiting a significant degree of arteriosclerosis with hypertension.

It is difficult to appraise the incidence of massive bleeding from diverticular disease. Quinn and Ochsner [*7*] published a review of the experience at Charity Hospital. Over a ten-year period seventy-six patients were admitted for complications of diverticulitis or diverticulosis. Thirty-seven or 48.7 per cent of these were hospitalized primarily because of hemorrhage, and in twenty-three of these thirty-seven the bleeding was judged to be really massive. Welch, Allen and Donaldson [*8*] reviewed 582 cases of diverticular disease and found five cases in which hemorrhage was the major indication for surgery. In 1955 Noer

[1] reviewed forty-one cases of massive hemorrhage from eighteen papers published since 1942 and added two cases from his own experience, both of which required surgery. It is evident that while statistically not common, massive melena from diverticular disease does occur frequently enough to deserve consideration.

A major problem in the diagnosis of hemorrhage from diverticulosis lies in the fact that it can be reached only by excluding other lesions which could cause bleeding. Since it is impossible to demonstrate a bleeding diverticulum by any direct test or examination, one must arrive at a presumptive diagnosis by process of elimination. Ochsner [7] has proposed the following criteria: (1) passage of gross rectal blood, bright or maroon in color; (2) evidence of diverticula on barium enema; (3) absence of other intrinsic lesions on rectal and proctoscopic examinations; and (4) normal stomach and small bowel on gastrointestinal examination. It may, of course, be impossible to perform all of these examinations on a patient who has lost a large amount of blood from acute hemorrhage. Surgical exploration as a method of diagnosis is highly unsatisfactory. Laparotomy during active bleeding typically reveals only a colon filled with blood in which multiple diverticula are present. Colotomy with operative endoscopy is of little value in localizing the bleeding point. The problem of detecting the site of bleeding in a colon filled with blood can be appreciated when one realizes that the mucosal erosion responsible for the hemorrhage is generally so small that it escapes detection even on the resected specimen or at necropsy examination [2,3,7,9].

In view of the difficulties involved in localization of the bleeding diverticulum at surgery, we may well inquire into the prognosis in nonoperated patients. The majority of patients will respond to conservative management and a cessation of bleeding may usually be expected to follow a program of rest, sedation, transfusions and intestinal antiseptics. Moreover, many of these patients remain well indefinitely without further hemorrhage. Certainly conservative treatment should be employed initially in all cases of hemorrhage of the large bowel.

However, most surgeons of wide experience agree that an occasional patient will continue to bleed and that the possibility of exsanguinating hemorrhage from this source, while not great, is real. In the patient whose bleeding cannot be controlled by conservative management with repeated transfusions, surgical intervention is mandatory. At laparotomy the first objective is to make a definite diagnosis, if possible. The entire colon should be examined carefully for evidence of tumor, polyp or inflammatory process. When no abnormality other than diverticulosis is noted the surgeon is faced with a difficult decision. If the diverticula are limited to a portion of the colon, the involved segment should be resected. If, however, the entire large bowel is involved and no localization of the bleeding site is possible, the problem is great. In this circumstance four possible courses are open: (1) closure of the abdomen and dependence on conservative measures; (2) total extirpation of the abdominal colon; (3) blind resection of the most involved segment (usually the sigmoid); and (4) formation of one or more localizing colostomies, or precolostomies as advocated by Peters [3]. To do nothing in the face of continuing hemorrhage is obviously unsatisfactory. Total colectomy with an unprepared bowel in a poor risk patient who has lost a lot of blood is a formidable procedure and may not be practical. Generally the sigmoid region exhibits the most extensive diverticulosis and on the basis of probability is most likely to be the source of bleeding [5]. Resection of this segment may be expected to remove the bleeding point in most but certainly not all cases. The alternate method, that of making colostomies, provides for diversion of the fecal stream and makes possible the introduction of intestinal antiseptics and topical coagulants. This course of action is open to the criticism that no direct attack is made upon the source of the hemorrhage. If hemorrhage does continue, however, the presence of colostomies may aid in localization and permit a more conservative resection at a later operation. It is apparent that no clear course is open to the surgeon faced with emergency surgery in a problem of this kind.

When the situation is somewhat less urgent, further diagnostic study is possible and a more leisurely evaluation can be made. If, because of recurrent bleeding or because malignant disease cannot be ruled out, surgery is decided upon, elective resection of the involved colon may be accomplished after adequate bowel preparation. Since inflammatory reaction is

generally minimal or absent, resection and anastomosis may be performed safely in one stage.

The following previously unreported case is presented because of several unusual features which are thought to be of interest.

CASE REPORT

A. L., a forty-three year old white man, was admitted to the hospital on December 7, 1951. He had had no gastrointestinal symptoms prior to the day of admission and except for an appendectomy two years previously his past medical history was entirely negative. At 3:00 A.M. he was awakened by a sudden urge to defecate and passed a large amount of red blood. He experienced mild nausea but did not vomit and there was no abdominal pain. After passing two more large bloody stools he complained of weakness and faintness and was hospitalized. On admission there was no evidence of active bleeding and his blood pressure was 130/90 mm. Hg. General examination was negative and anoscopic examination revealed no blood in the distal rectum. Hemoglobin on admission was 13.6 gm. per cent with a red blood cell count of 4,020,000 per cu. mm. and a white blood cell count of 15,500 per cu. mm.

About twenty hours after his initial episode the patient again began to bleed per rectum, passing an estimated 2 to 3 pints of bright blood and clots. The pulse became rapid and to combat shock blood transfusions were started. Sigmoidoscopy was attempted but no lesion was found, and active flow of blood was observed to be coming from a level above the range of visibility. After a transfusion of 1,500 cc. of blood the patient was stabilized but he continued to pass an occasional bloody stool for the next forty-eight hours and the hemoglobin dropped to 9.4 gm. per cent. Barium enema examination was performed after the bleeding stopped and revealed only diverticulosis confined to the region of the hepatic flexure. (Fig. 1.) Upper gastrointestinal series showed no pathologic condition and sigmoidoscopy repeated after preparation again revealed no lesion. The patient was discharged from the hospital to return for further studies at a later date, but on December 17th, ten days after his initial admission, he again began to pass blood per rectum. He was rehospitalized for observation but no transfusions were required on this admission. Barium enema examination was repeated and again showed only the localized diverticulosis. On January 18th, after passing another blood stool, the patient was admitted for elective surgery after bowel preparation. Exploration failed to reveal any pathologic condition other than the diverticulosis. Careful examination of the entire large bowel showed only the diverticula of the cecum and ascending colon, some of which contained inspissated fecal matter. Right hemicolectomy was performed with primary end-to-end iliotransverse colostomy. The patient made an uneventful recovery and has remained well with no further hemorrhage for a period of five years.

FIG. 1. Barium enema x-ray showing diverticulosis limited to the proximal colon.

Examination of the specimen revealed numerous diverticula of the ascending colon, one of which, located 8 cm. from the distal end, showed diffuse hemorrhage with typical ecchymotic discoloration. (Fig. 2.) Microscopic examination showed a typical false diverticulum with ulceration of the mucosa and evidence of acute submucosal hemorrhage. (Fig. 3.)

COMMENTS

While this case presents the typical onset and course of moderately profuse hemorrhage from a diverticulum, the patient was somewhat younger than the usual person exhibiting well developed diverticulosis. Also, he showed no evidence of the arteriosclerosis and hypertension usually found in patients bleeding from this condition. Moreover, the diverticula were confined to the proximal colon which is unusual. Finally, contrary to the general rule, we were able to demonstrate the actual bleeding point in the specimen (something which has been possible in only two reported cases [*1*,*6*]), thus confirming the diagnosis. The decision to operate in this case was made on the basis of recur-

FIG. 2. Photograph of the diverticulum from which hemorrhage occurred, showing ecchymotic discoloration of the mucosa.

FIG. 3. Photomicrograph of the bleeding diverticulum showing submucosal hemorrhage and erosion of the mucosa.

rent hemorrhage in a good risk patient with localized disease.

CONCLUSIONS

While exsanguinating hemorrhage from the large bowel is not common, massive bleeding does occur from colonic diverticula and will occasionally proceed to a fatal termination unless there is surgical intervention. In view of the evident problems involved in the operative treatment of this condition the initial program should be conservative in all cases. The difficulty lies in recognizing before the patient becomes a prohibitive surgical risk, those cases which will not respond to medical measures. As has been suggested, one should be guided by some policy comparable to that which has been generally accepted for massive bleeding from the upper gastrointestinal tract [2].

SUMMARY

The consensus of thought regarding the formation of colonic diverticula and the mechanism by which bleeding occurs has been reviewed. The problems involved in the surgical treatment of those cases in which hemorrhage has not been controlled by conservative meas-

ures has been discussed. A case showing some unusual features has been presented.

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Fistulotomy and Fistulectomy for Fistulas about the Anus and Rectum

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THE purpose of this paper is to record certain data pertinent to the technics of fistulotomy and fistulectomy, and the use of single and multiple stage operations which will aid the rectal surgeon in selecting the procedure of choice for any given patient. It is not intended to show one technic to be generally superior to the other, for excellent results are obtained with both, bearing in mind that factors other than sphincteric continence operate in obtaining as nearly a normal anorectum as is possible.

For purposes of this discussion the terms fistulotomy and fistulectomy will be used to imply single and multiple stage procedures, respectively, although admittedly this is not necessarily the case.

Basically, fistulotomy entails incising the fistulous tract and its ramifications over a probe from the external opening to the internal opening, usually in one stage. This has been done regardless of sphincteric involvement [*11*]. Fistulectomy, although it is often applied to superficial fistulas, is frequently reserved particularly for those fistulas involving the anorectal musculature and is then almost invariably performed as a staged procedure. It involves actual extirpation of the fistulous tract as a tube of tissue from the external opening to the internal opening, producing in effect a surgical fistula. A seton is then left around the remaining muscle and is removed by incision of that muscle over a probe at a later date. This second stage is usually performed as an office procedure under local anesthesia about ten to fourteen days following the initial surgery.

Since both procedures are accepted and give equally good results, to a great extent the one chosen will depend upon how the surgeon was trained and whether or not he has a natural inclination to adopt more conservative methods. In the vast majority of cases there will be no significant difference in the end result to the patient regardless of which procedure is used.

The ultimate goal of the surgery is the eradication of the disease. However, in the process there are certain aims to be desired. The technic should: (1) be simple, (2) be highly adaptable, (3) sacrifice a minimum of tissue, (4) result in a minimum of sphincteric dysfunction, (5) result in as little outlet deformity as possible and (6) entail as little morbidity as possible. It is with these factors in mind that an evaluation will be made.

Fistulotomy is certainly the simpler of the two technics, requiring much less effort but certainly no less scrutiny on the part of the surgeon. It has been used with success on all types of fistulas regardless of the amount of sphincter involved. The incontinence resulting from fistulotomy is ultimately no greater than that resulting from a staged procedure if properly cared for postoperatively. Immediately postoperatively, before healing has taken place, there may be a period of temporary sphincteric dysfunction. It is to be noted that in many instances, at surgery, good sphincter tone returns as the anesthetic wears off in spite of division of the sphincter. When incontinence is present during this immediate postsurgical period it is because the cut ends of the sphincter are not fixed. The tendency is for the interval between the severed ends of the sphincter to be increased by the contraction of the muscle when there are bowel contents to be retained. This is especially true of lateral fistulas. Actually this temporary incontinence does not inevitably ensue. It attends the postoperative period only on occasion, depending upon how

much of the sphincter was cut and on the continuity of the anorectal fibromuscular ring.

Advocates of two-stage procedures state that this type of sphincteric dysfunction is obviated because at no time is the circumference of the sphincter disrupted until sufficient scarification has taken place in the process of healing to prevent the subsequently incised ends of the sphincter from separating farther.

The adaptability of fistulotomy is almost universal. It has limitations in those fistulas in which the tract is so contracted that it cannot be followed with a probe. Under these circumstances the surgeon must excise that portion of the tract as is done in fistulectomy.

Fistulectomy is equally adaptable but also has its limitations. It is not applicable in those cases in which the tract has not contracted but is spacious, e.g., when definitive curative surgery is performed on acute abscesses or shortly after their incision and drainage. At times a chronic fistula will also have a lumen of wide diameter with ill defined walls. In these cases staged fistulotomy, if sufficient muscle is involved, is an excellent procedure and has many features to recommend it.

Fistulotomy, properly performed, will sacrifice little or no tissue not already destroyed by the inflammatory process. Because of this it follows that there ultimately should be little muscular dysfunction due to surgical loss of tissue.

Slight incontinence in the form of soiling is not uncommon after surgery for fistulas. Should there be relaxation of the outlet with separation of the ends of the muscle after fistulotomy, the probability of this late complication occurring is increased. It is a direct result of deformity at the outlet. Again, this is especially true of laterally placed fistulas where the stress tending to cause wound separation is more perpendicular to the line of incision.

Rectal surgeons have long considered flat scars desirable in the healing of their surgical wounds. This is because flat scars indicate healing from the base of the wound minimizing the tendency to bridge. Also, if a wound heals with a flat scar there is less danger of decreasing the caliber of the outlet. The amount of deformity of the anus after surgery for fistulas will depend upon the texture and extent of the scar formation and the degree to which those scars will ultimately become depressed. Flat scars at the outlet will cause more deformity than will linear scars, given a fixed degree of depression, but in any given case the amount of depression is the more significant of the two factors. Fistulotomy may result in either linear or flat scars, including all gradations between, depending upon how much the wound gapes; however, it will almost always result in a more depressed scar than would a staged operation in the same instance.

In general, the morbidity attending surgery for fistulas is less than one might expect. Depending upon the extent of the disease, the patient is usually back to work in approximately ten days. He need only be concerned with keeping himself clean and free of discharge during the period of healing.

The technic of fistulectomy, in sharp contrast to that of fistulotomy, is a much more trying procedure. It frequently requires meticulous dissection. At times fistulectomy cannot be performed with a probe lying in the tract. When this is the case many surgeons will instill a dye to identify the tract and its internal opening. It is not uncommon for the tract to be so narrow as to prevent the free flow of a dye throughout its entire extent. Under these circumstances the surgeon must be prepared to palpate the course and extent of the fibrous cord between his fingers as he proceeds gingerly with his dissection. This can be very delicate and is most demanding of the rectal surgeon.

By the very nature of the surgery, one can see that at least a few millimeters of healthy tissue around the tract must be removed simultaneously when performing fistulectomy. This may be scar tissue, muscle or fat. Frequently only a few fibers of the subcutaneous portion of the external sphincter will remain distal to the surgical fistula. For practical purposes their significance is negligible. They frequently will atrophy or be severed by a bowel movement before they can be incised for removal of the seton.

If a larger portion of muscle is involved the value of a staged procedure becomes more evident. While more tissue may be sacrificed by fistulectomy, actually no more sphincteric dysfunction follows. Moreover, the tendency for initial incontinence to occur is obviated because the circumference of the sphincter is still intact. Because of this there is also less deformity at the outlet of the anal canal. The segment of muscle preserved also serves as a foundation over which epithelization may

occur and constitutes an additional factor in the prevention of outlet deformity. Furthermore, it reduces the tendency for the scar to be depressed.

A factor considered of importance by some is the stimulus to the production of granulations by the seton which acts as a foreign body or physical irritant. In this manner it supposedly enhances the formation of scar tissue and healing.

An additional consideration is that the technic of fistulectomy actually removes all of the infected tissues. Assuredly, this can be left to natural processes; however, it has been stated that fistulectomy wounds heal more quickly because the tract wall is removed [7].

A deterrent to a two-stage procedure is the fact that it is not always easy or desirable to have to explain to a patient that he must undergo two surgical procedures, however simple the second one may be. This psychic trauma is something with which to contend in only an occasional patient. The added physical morbidity imposed on the patient by the minor procedure is in most instances negligible and if the patient can be made to accept it psychologically, as the overwhelming majority can, then the psychic morbidity is also minute.

From the economic standpoint a staged procedure produces no hardship for ordinarily no added disability is involved.

At this point it would be well to consider the following question: Is a two-stage procedure actually a more conservative approach to the problem of fistulas?

CONCEPT OF AVASCULAR SEGMENTAL ATROPHY OF THE ANORECTAL SPHINCTER

In general fistulectomy with the intention of preserving the circumference of the sphincter is considered the more conservative approach in surgery for fistulas. Under certain conditions, however, this is decidedly not the case.

It is my contention that a certain amount of atrophy of the remaining segment of the sphincter takes place after excision of the fistula. The degree to which this occurs varies directly with the size of the surgical defect left by the fistulectomy proximal and peripheral to the segment, and inversely to the amount of tissue the segment contains. It is believed that this atrophy is based upon devascularization due to surgery, and that the arteriolar and capillary circulation which remains is not sufficient to sustain or maintain the integrity of the segment. As a result a gradual attenuation and thinning out takes place. This may be great enough to cause the entire segment to disappear so that the seton is passed spontaneously, as evidenced by the patient reporting that the "string" was found lying free on the dressing, or by the patient reporting that it was found in the toilet bowl after an evacuation in which case the added stress of a bowel movement was sufficient to sever the few remaining sphincter fibers. It is very doubtful that first stage fistulectomy properly performed in a patient in whom it was indicated will leave an amount of sphincter behind which can be disrupted by bowel movements unless they are unusually difficult or explosive. Usually an element of attenuation has also been imposed. This statement is made because of skepticism expressed by some proctologists toward the idea that atrophy plays any significant role in the fate of the sphincteric segment. If the peripheral defect and the defect in the anorectal wall are great enough, even frank necrosis with a resultant slough of the sphincteric segment may occur. This can be tragic for complete incontinence and procidentia may occur.

An inevitable consequence of fistulectomy is a variable amount of myofibrosis in the segment. It is well known that striated muscle does not regenerate and heals with a scar of fibrous connective tissue. This is evident also in the myocardium of a patient with arteriosclerotic heart disease in which a diffuse fibrotic process may occur as a result of gradual, long-standing deprivation of blood supply. The texture with which the segment cuts during the second stage testifies to the fibrous infiltration in the muscle tissue.

With the intention of eliminating some of the disadvantages of fistulectomy, an excellent procedure employed has been a technic in which the muscular portion of the fistula is merely setonized without being involved in any dissection. It is subsequently treated by simple incision (fistulotomy) as a second stage. Actually the peripheral portion of the fistula may be treated by either fistulectomy or fistulotomy. Many rectal surgeons are of the opinion that fistulectomy should never be performed through the muscular portion of the fistula [3] and they employ this procedure routinely if a staged operation is considered necessary. However, surgical exploration of the muscular

portion of the fistula is of utmost importance at the initial operation whether the primary procedure is fistulectomy or fistulotomy. Actually proponents of the latter procedure insist that a search for tributaries of the main tract is greatly facilitated by fistulotomy when performed completely as the initial procedure. It must also be borne in mind that fistulotomy in the region of the sphincter is subject to the same limitations as is fistulotomy anywhere, as mentioned earlier.

If, prior to the dissection of the tract in the region of the sphincter, it can be predicted that a negligible amount of muscle will remain, it is better not to risk atrophy but to follow the remainder of the tract with a probe and to cut down on it.

Likewise, if the fistulous tract is involved in a large amount of scar tissue which may or may not be permeated by additional communicating sinus tracts, it would be better merely to incise the main and secondary tracts rather than to attempt to excise all of the involved tissue for this would leave a greater defect than is desirable and may eventuate in catastrophe.

SUMMARY

It is believed that a two-stage procedure should be performed when possible and especially in laterally placed fistulas in which the stresses tend to separate the wound and in anterior fistulas in the female where muscular support is less. A one-stage procedure should be performed if the amount of muscle involved is insignificant and there is danger of atrophy of the remaining fibers. A one-stage procedure should also be reserved for those cases which involve great masses of scar tissue which may or may not be permeated by sinus tracts as in watering-pot fistulas. The advantages and disadvantages associated with complete extirpation of the tract as compared to its simple incision are also discussed. As a rule the former is to be preferred but segmental atrophy of the sphincter must be borne in mind as a significant factor causing ultimate outlet deformity and muscular dysfunction.

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Basal Cell Carcinoma of the Anus

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The purpose of this paper is to report an additional case of a patient with basal cell carcinoma of the anus, only forty-seven cases having been described in the literature to the time of writing. Diagnosis is no problem if the entity is kept in mind, but the form of treatment has not been standardized.

Of 1,700 cases of carcinoma of the anus and rectum reported by Gabriel [*8*], only fifty-nine originated in the anus and only one was a basal cell carcinoma. Lawrence [*14*] reported 635 cases of carcinoma of the anus and rectum, two of which were basal cell carcinomas of the anus. Bacon [*2*], in reviewing 1,506 cases of carcinoma of the colon, found only two basal cell lesions of the anus. In 802 cases of cancer of the anus and rectum, Sweet [*23*] reports thirty-eight primary anal lesions, none of which were basal cell carcinomas. In 30,000 proctoscopic examinations at the Ochsner Clinic only five primary carcinomas of the anus were found, all of which were of the squamous cell type [*12*]. The cases reported are recorded in Table 1.

CASE REPORT

A ninety-three year old white man entered the hospital complaining of rectal bleeding of seven weeks' duration. He had been aware of a mass in the anus for a similar period of time, and stated he had passed tarry, foul-smelling stools for four weeks before admission. Examination revealed a moist, ulcerated, fungating lesion measuring 6 to 8 cm. in diameter involving the circumference of the anal orifice. The mass was firm and tender. On proctoscopy the mass was found to be approximately 4 cm. in length. No abnormalities were noted above the tumor. Biopsy was reported as basal cell carcinoma of the anus. Combined abdominoperineal resection would have been performed except for his advanced age and generally poor state of health. Sigmoid colostomy was performed in preparation for treating the lesion with radiation. The patient did well for nine days postoperatively when he suddenly died from myocardial infarction. At postmortem no extension of the tumor beyond the local lesion was found.

COMMENTS

Basal cell carcinoma of the anus occurs more frequently in men than in women, a ratio of 3:1 in the recorded cases. (Table 1.)

The age of the patients reported previously ranged from forty-three to eighty-two, thirty-two of the forty-three cases in which the age is given being in the age range from fifty to seventy. Only two cases have occurred in persons under the age of fifty. The average age of men at the time of diagnosis (61.8 years) is only slightly less than that of women (64.6 years).

In the twenty-six cases in which the symptoms are reported, those of an anal mass (ten cases), rectal discharge or bleeding (eight cases), hemorrhoids (seven cases), pruritus ani (seven cases) or ulcer (four cases) are most frequent. In these cases the symptoms tend to be chronic in nature, the average duration of symptoms before diagnosis and treatment being 5.3 years. In only twelve cases were the symptoms of less than one year's duration.

As symptoms in basal cell carcinoma of the anus are not pathognomonic of the disease, it may not be recognized until tissue removed in treatment of other anal disease is examined microscopically (Cases 6, 7, 21, 23, 28). In one case the tumor was excised without being recognized as a basal cell carcinoma of the anus. The correct diagnosis was made two years later when a recurrence was excised (Case 21). In another case three operations were performed before the true nature of the disease was recognized (Case 6). The fact that basal cell carcinoma of the anus is frequently associated with, and may be masked by, other disease of this region should be borne in mind

TABLE I

SUMMARY OF CASES OF BASAL CELL CARCINOMA OF THE ANUS REPORTED TO 1957

Case No.	Author	Age (yr.) Sex	Symptoms	Clinical Findings	Treatment	Follow-up
1	Pennington, 1923	53, M	Pruritus ani, 6 yr.; hemorrhoids, 2 yr.; fissure in ano, 6 mo.	Nodule in fissure; biopsy: basal cell carcinoma	Radium advised	None
2	Wallon, 1927	63, M	Hemorrhoids, itching anal vegetations, 4 yr.	3-4 cm. mass; biopsy: basal cell carcinoma	Colostomy; radium therapy; colostomy closed	7-mo., apparent cure
3	Rosser, 1931	77, F	Hemorrhoids, blood and pus per rectum, 30 yr.	Indurated area and tumor	Not given	Not given
4	Buie and Brust, 1933	53, F	Symptoms, 1 mo.	Annular lesion	Colostomy; posterior resection; half of vagina and local nodes removed; radium	8 mo., recurrence; died 1 mo. later
5	Buie and Brust, 1933	53, F	Symptoms, 30 mo.	Hard nodule size of orange and mass in left groin	Radium advised; patient went home without treatment	None
6	Guess, 1935	52, M	Protrusion from anus, 6 mo., and fissure Papilliform growth Papilliform growth 2 cm. ulcer	Excision, no pathologic examination Excision, no pathologic examination Excision, no pathologic examination Excised basal cell carcinoma	Excision; interstitial radium	5 yr., no recurrence
7	Tucker and Hellwig, 1938	43, M	Bleeding per rectum, 2 yr.	Hemorrhoids, basal cell carcinoma found on pathologic examination	Excision; radiation; radium	3 yrs., no recurrence
8	Gabriel, 1941	70, M	2 yr.	2 cm. flat ulcer	Excised	12 mo., well
9	Lawrence, 1941	68, M	"Piles" and rectal incontinence, 11 mo.	Large mass 6 cm. in diameter	Loop colostomy; Posterior resection, left gross tumor	3 yr.; died, cause unknown
10	Lawrence, 1941	73, F	Growth on anus, 1 yr.; discharge and bleeding	Annular fungating growth extending into perineum and perianal tissue	Loop colostomy; abdominal exploration; posterior resection	Died 26 days postoperatively
11	Gabriel, 1948	63, F	"Blister" about anus, 3 yr.	1 cm. flat papule with raised edges	Excised	3 yr., well
12	Gross, 1948	49, M	Itching about anus, 1 yr.	2 cm. ulcer	Excised	2 yr., no recurrence
13	Roux-Berger, 1949	No details given	. . . . .	. . . . .	. . . . .	. . . . .
14	Wakely and Childs, 1949	72, M	Ulcer, 4 yr.	2 cm. ulcer of anus	Excised	No follow-up
15	Wakely and Childs, 1949	64, M	Pimple present several years	2 cm. ulcer	Excised	No follow-up
16	Wakely and Childs, 1949	56, M	Lump, 5 yr.	Irregular, small ulcer	Excised	No follow-up
17	Wakely and Childs, 1949	59, M	5 yr.	Small, irregular ulcer	Excised	No follow-up
18	Lott and Alexander, 1949	62, F	Itching and irritation about anus	2 by 1 cm. nodule beneath anal mucosa	Excised; radiation	6 mo., well
19	Bernstein, 1949	82, M	Knife-like pain on defecation	Painful, raised area at upper margin of anal wall	Excised locally	Died 2 days postoperatively
20	McQuarrie and Buie, 1950	50, M	Protruding hemorrhoids, 8 yr.; rectal bleeding, 4 yr.	External and internal hemorrhoids; small area of dermatitis and underlying induration	Excised locally; radium	2 yr., no recurrence
21	McQuarrie and Buie, 1950	53, M	Anal trouble, 7 yr.; pruritus ani treated with x-ray and cautery; anal ulcer, 4 yr., excised 2 yr. before	3 by 1.5 cm. ulcer at posterior margin of anus	Excised locally; radium	1 yr., no recurrence
22	Gross, 1951	71, M	. . . . .	Anal lesion	Local excision	2 yr., no recurrence
23	Hall, 1952	58, M	Hemorrhoids and "granuloma"	Hemorrhoids and granuloma at proctoscopy	Hemorrhoidectomy; excision of granuloma	No recurrence
24	Armitage and Smith, 1954	59, M	Sore place, 1 yr.	2 cm. chronic ulcer with hard edges at anal margin	Local excision	3 yr., well with no recurrence
25	Armitage and Smith, 1954	60, F	Piles, 6 mo.	2.5 cm. malignant ulcer at anal margin	Radium needles followed by excision	4 yr., no recurrence; died, carcinoma of breast

Continued on page 824.

TABLE 1 (CONTINUED)

SUMMARY OF CASES OF BASAL CELL CARCINOMA OF THE ANUS REPORTED TO 1957

Case No.	Author	Age (yr.) Sex	Symptoms	Clinical Findings	Treatment	Follow-up
26	Armitage and Smith, 1954	64, M	None	2.5 cm. ulcer at anal margin	Radium needles followed by excision	3 yr., well with no recurrence
27	Armitage and Smith, 1954	69, F	Ulcer, blood and mucus per rectum, 3 yr.	7 by 10 cm. growth involving entire anus	Radium needles followed by colostomy	Died, 6 yr. of metastases from carcinoma of rectum
28	Klippel and Tomlinson, 1954	65, M	"Sore" on rectum 3 yr.; fistula-in ano Pain recurred	Basal cell carcinoma in fistula Granulomatous tissue around posterior anal margin	Fistulectomy Biopsy; 5,000 radiation, abdominoperineal resection	3 yr., no recurrence
29	Martineau et al., 1954	62, M	Hemorrhoid, 5 yr.; rectal prolapse, 1 yr.	2 by 2 by 5 cm. mass involving two-thirds of anal margin; hemorrhoids	Excised locally; radiation	1 yr., no recurrence
30	Burns, 1955	64, M	Rectal bleeding, tenesmus, 3 mo.	4-5 cm. ulcerated tumor at and above anal canal	Proctosigmoidectomy	10 mo., recurrence with pelvic metastases
31	Manheim and Alexander, 1955	72, M	Fistula-in-ano, 20 yr.	Fistula-in-ano	Excised	4 yr., well
32	Chilese and Schevalzon, 1955	No details given	. . . . .	. . . . .	. . . . .	. . . . .
33	Bacon, 1956	No details given	. . . . .	. . . . .	. . . . .	. . . . .
34	Bacon, 1956	No details given	. . . . .	. . . . .	. . . . .	. . . . .
35	Matt and Dilger, 1956	66, F	Sore about anus, 4-5 yr.; sores on back	2.5 by 3 by .5 cm. mass at anal orifice (also 4 basal cell carcinoma of back)	Excised locally with electrocautery	None
36	Fitchett and Baker, 1956	73, M	Growth about anus, 2-3 yr.; itching, bleeding	Cauliflower-like growth encircling anus, extended 1 cm. within anus	Biopsy; radiation	2 yr., no recurrence
37	Case and Caldwell, 1956	72, F	Pain on defecation 2 wk.	4 by 4 cm. indurated mass above pectinate line and involving rectovaginal septum	Biopsy; radiation with subsequent slough; colostomy	Died of heart disease 6 mo. following radiation
38	Wittoesch et al., 1957	60, M	29 yr.	Not given	Excised locally	13 yr., no recurrence
39	Wittoesch et al., 1957	50, M	4-8 yr.	Not given	Excised locally; radiation	12 yr., no recurrence
40	Wittoesch et al., 1957	53, M	10 yr.	Not given	Excised locally	6 yr., no recurrence
41	Wittoesch et al., 1957	60, M	9 mo.	Not given	Excised locally	6 yr., no recurrence
42	Wittoesch et al., 1957	74, M	10 yr.	Not given	Excised locally; radiation	3 yr., no recurrence
43	Wittoesch et al., 1957	55, M	4 yr.	Not given	Excised locally	None
44	Wittoesch et al., 1957	68, M	Not given	Not given	Excised locally; radiation	Died, 4 yr. of carcinoma of prostate
45	Wittoesch et al., 1957	63, F	1 yr.	Not given	Excised locally	3 yr., no recurrence
46	Wittoesch et al., 1957	70, M	1 yr.	Not given	None	None
47	Wittoesch et al., 1957	66, M	1 yr.	Not given	Excised locally	None

if the correct diagnosis is to be made and early and proper treatment instituted.

The most frequent clinical finding was that of a mass (fifteen cases), the masses varying from 1 to 6 cm. in diameter. Ulcers were associated with the lesions in twelve cases, with hemorrhoids in eight cases and with fistula-in-ano or fissure in four cases.

Treatment in the reported cases has consisted of local excision in nineteen, extended excision with and without radiation in five, local excision with preoperative or postoper-

ative radiation in eleven, and radiation therapy alone in four. Treatment was refused by the patient in three cases and details of treatment are lacking in five cases. Follow up on these cases has been of short duration, averaging 3.3 years. Of the thirty-two cases in which details of follow up are available, there were three postoperative deaths and two deaths from recurrences nine months and six years after treatment, respectively. One patient, in whom gross tumor was left at operation, died three years after treatment; two patients died of carcinoma of the breast and prostate, respectively, four years after treatment but without evidence of recurrence of the anal lesion. The patients in Cases 4, 5 and 27 showed evidence of metastases and probably do not represent true basal cell carcinomas. In Case 37 there was recurrence at ten months with pelvic spread. Of these thirty-two cases, twenty-six (80 per cent) had no recurrence during the period of followup.

Basal cell carcinoma of the anus, when adequately treated, has an excellent prognosis. In view of the efficacy of local excision with or without postoperative radiation in the cases reported, this treatment would appear to be adequate for most patients.

SUMMARY

1. Basal cell carcinoma of the anus is a rare disease, only forty-seven cases having been previously reported.

2. Another case of basal cell carcinoma of the anus has been reported in this paper.

3. Basal cell carcinoma of the anus must be borne in mind if the diagnosis is to be made and proper treatment instituted.

4. The prognosis for basal cell carcinoma of the anus is good if the condition is adequately treated.

5. Local excision with or without postoperative radiation is adequate treatment for basal cell carcinoma of the anus.

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Management of the Bowel after Hemorrhoidectomy with a Standardized Senna and Wetting Agent Preparation

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ONE of the most distressing phases following hemorrhoidectomy is the first bowel movement, and subsequent ones, if bowel management is complex or ineffective. The routine enema postoperatively is gradually being supplanted by an attempt at as near physiologic defecation as is consistent with an anorectum in a state of surgical recovery.

The ideal routine for postoperative management of the bowel has been my quest for some years. The impressive results obtained in a previous clinical study [*1*] of the management of constipation with a standardized senna preparation (senokot), and the recent availability of a wetting agent (dioctyl sodium sulfosuccinate) [*2,3,4*] stimulated the present clinical investigation.

It appeared that this combination might qualify for the two basic principles involved in bringing about spontaneous postoperative defecation: (1) stimulation of defecation reflex neurogenically and (2) production of a malleable stool that would adapt to the inelasticity of a recently sutured anorectum. On this basis the following study was conducted to evaluate a preparation* containing 225 mg. of standardized senna plus 50 mg. of dioctyl sodium sulfosuccinate in capsule form.

CLINICAL MATERIAL

Seventy-five patients upon whom hemorrhoidectomy was performed were treated with the senokot/dioctyl sodium sulfosuccinate preparation.

The age incidence was from sixteen to seventy-eight years. Surgical technic was standardized as well as all other methods of postoperative management. The only inconstancy was the variation in bowel habits in this group of patients.

METHOD OF ADMINISTRATION

Medication was started on the first postoperative evening according to the probable dosage required. This was estimated on the basis of past bowel habits. Those patients who usually experienced a daily elimination without irregularity were started on one to two capsules nightly. If the history showed that a previous laxative produced colonic hypermotility, the dosage was limited to one capsule. For those patients who presented some bowel irregularity, two capsules were administered at bedtime. If intermittent or constant use of laxatives was previously required, then three to four capsules were used as an initial dose. Dosage was increased or decreased according to the results obtained and tolerance of the patient. Table 1 indicates the dosage schedule that was followed.

It was found as the study progressed that the necessity for an enema could be further reduced by adequately assessing the potential of a given patient to have a spontaneous bowel movement and adjusting the dosage accordingly.

Treatment was continued for at least two weeks. However, if a spontaneous bowel movement did not occur on the fourth postoperative day a tap water enema was given.

RESULTS

More conservatism was exercised on dosage at the outset than in the latter half of this study. This was manifest in the relatively lower incidence of enemas required.

* Supplied by the Medical Department of The Purdue Frederick Company, New York, New York.

Fifty-seven (76 per cent) patients were able to have a spontaneous bowel movement on the second or third postoperative day, whereas eighteen (24 per cent) patients required an enema to initiate evacuation.

The criterion for a satisfactory postoperative result was that the stool be sufficiently soft in consistency so that its passage was accomplished with comparative or reasonable ease and that the number of stools per day be within the physician's control. Seventy-nine per cent of the patients who had a spontaneous bowel movement met this requirement, while the balance complained of either a somewhat firm stool or more than their usual number per day. On the other hand, the number of stools per day were more or less easily regulated subsequent to the day of the first bowel movement by adjusting the daily dosage. (Table II.)

TABLE I
DOSAGE SCHEDULE

No. of Capsules per Day	No. of Patients
1	15
2	28
3	22
4	10

TABLE II
EFFECTS OF SELECTIVE DOSAGE

Average No. of Stools Daily	No. of Patients
1	14
2	24
3	16
4	3

It was interesting to note that while senna is in the anthracene group [5], no evidence of melanosis coli was observed in any patient who was maintained on prolonged dosage, which was as long as four months in some cases.

CONCLUSIONS AND SUMMARY

The ideal bowel evacuant is of inestimable value postoperatively in patients who have undergone rectal surgery. A critical clinical study was made on seventy-five patients who had undergone hemorrhoidectomy and were given a combined standardized senna and dioctyl sodium sulfosuccinate preparation (senokap).

Bowel evacuation in the non-surgical patient is more easily accomplished since there are definite physiological disturbances of the defecation reflex following surgery as well as a natural anxiety about the potential of pain under such circumstance.

Two basic pharmacodynamics were sought to effect increased bowel motility without diarrhea if possible, and an adequate softening agent to permit feces to be reasonably malleable during defecation. Senokap appeared to satisfy these criteria and was thus evaluated.

The implementation of the first postoperative dejection by this preparation was impressive particularly in the latter half of the study when a better understanding of dosage was effected by clinical trial.

The relative freedom from side reactions and absence of toxicity gives the surgeon flexibility of dosage to give the necessary impetus to initial postoperative defecation. Subsequent maintenance proved to be simple management for the most part.

Further clinical evaluation in this direction is encouraged in order that some part of the ordeal of recovery following rectal surgery might be obviated.

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A Clinical Evaluation of Enzymatic Débridement with Papain-Urea-Chlorophyllin Ointment

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THE successful removal of necrotic, devitalized and infected tissue, particularly where it complicates a superficial lesion, has been the subject of continuous study probably for as long as the medical arts have been practiced, and over the years repetitive and renewed enthusiasm for one method after another has been reported in the medical literature. To stimulate and supplement natural processes without promoting damage through normal physiological barriers remains an abiding goal. The entire problem of effective débridement is a basic consideration in the realm of surgery.

A most logical search for a therapeutic compound which will attack dead tissue only and cause no injury to the surrounding viable, healthy parts occupies the full activity of untold numbers of investigators, and certain calculated criteria have evolved in the course of these investigations. Such a preparation must be, of itself, non-irritating, stable, easily applied and economically practical. The results of its application must be enduring, devoid of complication and of sufficient inherent safety as to require only a minimum of supervision, observation or manipulative technic. It must offer no hindrance to natural healing processes, must not be allergenic and must not stimulate the formation of antibodies. It must resist neutralization by other substances or medications, which may possibly be required concomitantly in the course of treatment, and the by-products elaborated during its function must be innocuous and readily neutralized or removable.

For a good many years the promise offered by enzymes of one category or another to satisfy these criteria has stimulated numerous critical studies pursuing varied lines and with comprehensive originality. One of the earliest references to the use of an enzyme may be found in the Bible, where it is described that, "Isaiah said: 'Take a bunch of figs.' They took and placed the figs on the ulcer and Hezekiah recovered" (II Kings: 20th chapt., 7th verse). In addition to corresponding agents elaborated from a variety of fruits and vegetables, there are similarly acting derivatives of animal origin, such as trypsin, pepsin, pancreatin and lysozyme, and of microbial origin, which include those prepared from the streptococcus (streptodornase-streptokinase), and a complex proteolytic agent found in clostridium histolyticus. All have been utilized in one form or another with varying and sometimes unpredictable results. In many instances, the agent was exceedingly expensive to produce and the achievement of anything approaching satisfactory results often demanded the use of such large quantities that the cure of the condition was rendered economically forbidding. Usually these agents were extremely unstable and could only be stored in powder form. Since these were applied in solution they required fresh preparation prior to each use and, even under the most explicit instructions, the preparations frequently were constituted improperly with negligible effect. On occasion, an otherwise innocuous solution was rendered highly irritating or otherwise injurious to viable tissue by the inadvertent loss or evaporation of component portions, or adequate effectiveness remained unrealized as a consequence of prompt dilution with suppurative material developing in the depths of the lesion. Intimate contact with necrotic tissue for

adequate periods of time was thereby difficult to achieve, and the inordinate nursing care necessary to insure continuous therapeutic action often stigmatized an otherwise useful derivative to the point of discard. Finally, most of these agents were available only in crude form and standardization was relatively impossible, contributing further to an uncontrolled impact and unfortunate loss of viable tissue. Conversely, overpurification achieved either the same result or lost effective components with ultimate impotency.

During an intensive search for a proteolytic enzyme from which these many disadvantages could be eliminated, the protease of the carica papaya eventually offered the greatest potential. The plant, often called the papaw or melon tree, is cultivated in tropical countries throughout the world but apparently it originated in the West Indies and along the Gulf of Mexico. The fruit has long been used for food and medicines prepared by natives, and commercial papain is the latex of this fruit. One of its first recognized medical uses was as a vermifuge in the seventeenth century [*1*] and its digestive activity has been documented since 1750 [*2*]. The first published experimental investigations appeared around 1875 [*3–5*], largely relating to the digestion of meat by papain solutions. In 1879, Wurtz and Bouchut [*6*] first named the papaya derivative "papain" and by 1880 there were pharmaceutical preparations of this agent which were considered useful in eczema, psoriasis, syphilitic ulcers of throat and tongue and as solvents of diphtheritic membranes of the throat. In 1888 Modder [*7*] used papain to speed the separation of slough in indolent ulcers, and Kilmer [*8*] in 1901 noted the same action of a papaya paste used in infected wounds by natives.

More recently a preparation of papain with hyaluronidase was used experimentally to liquefy cervical mucus in chronic endocervicitis; the favorable results in the treatment of infertility were reported by Kurzrok [*9*]. Glasser [*10*] in 1940 reported the results of treatment with papain in fifty-eight cases of sloughing wounds. Three years later Cooper, Hodge and Beard [*11*] published results of enzymatic débridement of six burn cases with papain. Other experimental studies included the use of papain solutions to prevent postoperative intraperitoneal adhesions [*12,13*]; in 1953 Guzman and Guzman [*14*] credited papain for the effective management of twenty cases of burns and ulcerations.

Extensive investigation carried on in recent years in France by several groups of observers such as Rigaud, Brisou and Babin [*15*], Joulia and Texier [*16*] and Coste [*17*] elicited enthusiastic reports, but American observers over the same period of time, among whom were such reliable research groups as Altemeier et al. [*18*] and Connell and Rousselot [*19*], reported with considerably less enthusiasm. The disparity in observed results naturally gave rise to much conjecture and consideration regarding the underlying reasons for these differences. However, whatever these reasons, they never quite occasioned total abandonment of papain as a useful proteolytic enzyme. Over a period of many months the authors engaged in tentative trials of a number of enzymatic products applied in many variations and combinations. By the simple process of elimination, a papain-urea-chlorophyllin ointment survived as a preparation of specific effectiveness in a wide range of conditions and, despite the fact that the investigation was conducted on purely clinical lines, the encouraging results were of sufficient significance to merit recording.

With this preparation the effective papain is supplied in stable ointment form and is immediately active when in contact with non-viable tissue, producing proteolysis even beyond the visual limits of tissue damage. In marked contrast to the effects of papain alone, there is little or no irritation or inflammatory reaction in the surrounding healthy tissue. In the past, inflammatory changes which accompanied the use of enzymatic débridement agents have been considered primarily a complication of prolonged presence of the agent and inadequate flushing or cleansing of the liquefied products of digestion. Barnard [*20*] demonstrated that proteolytic digestion produces substances which agglutinate red cells and, in turn, cause necrosis when injected under the skin of rabbits. Such substances in a wound area may therefore be considered potentially damaging to surrounding viable tissue. If the liquefied products of digestion, the protein and mucoprotein disintegrating products, are removed frequently, the inflammatory changes do not occur; but, since this is an unwieldy technic, an alternative device, consisting of the addition of another substance to the enzyme to prevent or neutralize the damaging

effects of the end products, is more appropriate. Water-soluble chlorophyll has been found to prevent hemagglutination and thereby renders the products of enzymatic activity innocuous to viable tissue. The urea is added to function as a type of solvent, thereby supporting or energizing the enzymatic activity. Urea does not of itself disintegrate protein or cause it to break down to its peptide components, but it affects the physical form of the protein without altering its chemical integrity. Its action may be thought of as an uncurling of fibrous proteins accompanied by molecular separation, thus increasing the exposure and enhancing the susceptibility of the protein matter to action of the proteolytic enzyme, effecting a more thorough and meticulous débridement of the necrotic area.

As a consequence of this logical combination of substances, the papain-urea-chlorophyllin ointment is applied without special precautions and it may be allowed to remain in contact with necrotic matter as well as surrounding healthy tissue for periods of twenty-four to forty-eight hours without removal and with complete safety. In many instances it serves to convert hospital treatment promptly to outpatient management and has been found to be entirely non-injurious in the hands of patients themselves. In some instances, a pink blush will appear in the skin surrounding the area under treatment and on occasion this has been regarded as indicative of inflammatory complication. However, careful observation over a reasonable period of time has proved that this represents only a type of telangiectatic reaction of no real significance from the standpoint of untoward effect. Rarely, a patient may complain of moderate stinging or burning immediately following the application of the ointment and lasting for a matter of a few minutes. This has not been a consistent complaint and in only one instance was there sufficient objection raised to warrant interruption of the treatment.

The period of study of the papain-urea-chlorophyllin ointment* as it was finally constituted covers approximately eight months. This ointment was evaluated from the standpoint of its individual effectiveness as a débriding agent and a meticulous comparison was made with other widely used enzymatic débridement agents, both as to efficiency and relative cost. The study was entirely clinical and objective, with progressive measurement of lesions, clinical appraisal and serial photographs, both in black and white and in color. The ointment was used in a wide variety of conditions, including pressure ulcers, burns and infections, degenerating and necrotizing neoplastic lesions, and metabolic and vascular complications such as diabetic and varicose vein ulcers. Pressure ulcers often were bilateral and offered excellent opportunity for autocontrol in the same individual.

From the very beginning of this study it quickly became apparent that this ointment was at least as effective as any other agent used and considerably less expensive. Its ease of application and its extreme stability permitted a significant saving in nursing care, dressings and equipment. One application daily sufficed for most conditions, although in large sloughing wounds dressings were usually changed twice daily. Foul, offensive ulcers were rendered free of odor without delay, thereby eliminating this most unpleasant concomitant with its deleterious effects on other patients as well as nurses, attendants and doctors. Wet dressings, used previously, which immobilized many patients, were conveniently exchanged for this more ambulatory type of treatment, serving thus to accelerate the general reparative processes. Table 1 shows that in many cases no specific or enduring healing had been accomplished by any previously used agent, while substitution of the papain-urea-chlorophyllin ointment ultimately produced the desired results, although on occasion a relatively extended period of time was required. Healing took place with re-epithelization rather than fibrosis or scar, and the new skin covering was durable with good blood supply and physiologic sensitivity. The new epithelium was initially quite thin and consequently a bluish discoloration accompanied the process but, with progressive proliferation of the tissue, this tended to fade into a more normal appearance as time went on. There was never any fixation to underlying bone in those instances in which the necrotic damage approached skeletal members and ordinary trauma was well tolerated by the new covering.

At no time was any attempt made to select cases for treatment, and every patient with any indication for débridement, regardless of the underlying pathologic condition, was accepted for this type of therapy. Even where good

* Panafil® ointment. Supplied by Rystan Company, Inc., Mount Vernon, New York.

TABLE 1

SUMMARY OF RESULTS OF TREATMENT WITH PANAFIL OINTMENT

Case	Primary Diagnosis	Complications	Initial Treatment			Duration of Subsequent Treatment with Panafil	Results
			Type	Duration	Results		
1	Diabetes mellitus	Severe streptococcal infection of right leg with unhealed drainage incisions	Bedrest, ace bandage, antibiotic ointments and irrigations with various solutions	3 mo.	Poor; residual chronic, indolent ulcers	1 mo.	Complete healing; re-epithelization with soft, elastic, normal-appearing skin
2	Diabetes mellitus	Severely infected callus in skin on plantar surface of first phalanx, left big toe	Surgical débridement followed by simple dressings	4 wk.	Continuation of purulent drainage	2 wk.	Complete débridement and healing with residual small sinus; this area then excised and treated satisfactorily with a split-thickness graft
3	Multiple wounds and abrasions of skin of both ankles	Gangrene of lower right leg	Surgical débridement and dressings with a wide variety of medications and technics	5 mo.	Occasional temporary improvement but ultimate gangrene of right leg with impaired circulation	3 days	Adequate and prompt débridement but circulation progressively more impaired; required amputation above the knee
4	Severe generalized arthritis; undiagnosed neurological disease	Pressure necrosis and inflammatory mass in mid-portion of back	.....	.....	.....	1 wk.	Adequate drainage and débridement followed by complete healing; similar area developed above left greater trochanter and was treated in same manner with panafil ointment; complete healing in 3 to 4 days
5	Generalized arteriosclerosis	Infection and patchy gangrene of toes and dorsum of right foot	.....	.....	.....	72 hr.	Prompt débridement, but impaired circulation of foot required amputation below the knee; stump healed well but was injured when patient fell on two occasions, complicated finally by ulceration of skin overlying tibia; treated with panafil ointment locally for 1 wk. with complete healing
6	Paraplegia	Severe decubitus ulcers of sacrum, right hip and right thigh posteriorly	Whirlpool baths, antibiotic ointments, improvised appliances for relief of pressure, and high protein and high vitamin diets	4 wk.	No improvement	60 days	Complete healing of sacral decubitus ulcer very promptly with some delay in healing of ulceration over hip area, but this too ultimately healed at end of extended period; no surgical interference necessary
7	Diabetes mellitus	Gangrene of toes of right foot	Surgical débridement followed by metatarsal amputation	2 wk.	Extensive necrosis of skin flaps with rapidly spreading cellulitis	2 wk.	Notable improvement in local area but uninterrupted spread of infection proximally as result of progressive arterial occlusion; ultimately required amputation above knee
8	Epilepsy	Large, deep, extremely foul decubitus ulcers of right greater trochanter and sacrum; severe offensive odor interfered with nursing care	.....	.....	.....	30 days	Adequate débridement and complete control of offensive odor; at time of report, ulceration over sacrum almost completely healed while that over greater trochanter is clean but not fully healed
9	Quadraplegia	Huge decubitus ulcer over right trochanteric area	.....	.....	.....	30 days	Healing practically complete at time of report, with only small residual sinus tract
10	Generalized arthritis	Ulceration of left heel	Hot wet dressings, a variety of ointments and varidase jelly	2 to 3 wk.	No improvement	3 wk.	Complete healing; no evidence of recurrence at 4 mo. follow-up
11	Burns of palmar and extensor surfaces of fingers of left hand	Chronic infection	Vaseline gauze dressings, "healing" and "sedative" ointments	3 to 4 wk.	Ineffective	3 wk.	Within 10 days re-epithelization so advanced that plan for skin grafting abandoned; at end of 3 wk. complete healing with unscarred skin
12	Lymphedema of both legs	Multiple ulcerations of both legs and elbows	.....	.....	.....	2 wk.	Total healing and complete disappearance of lymphedema

Continued on page 832.

TABLE 1 (*Continued*)

SUMMARY OF RESULTS OF TREATMENT WITH PANAFIL OINTIMENT

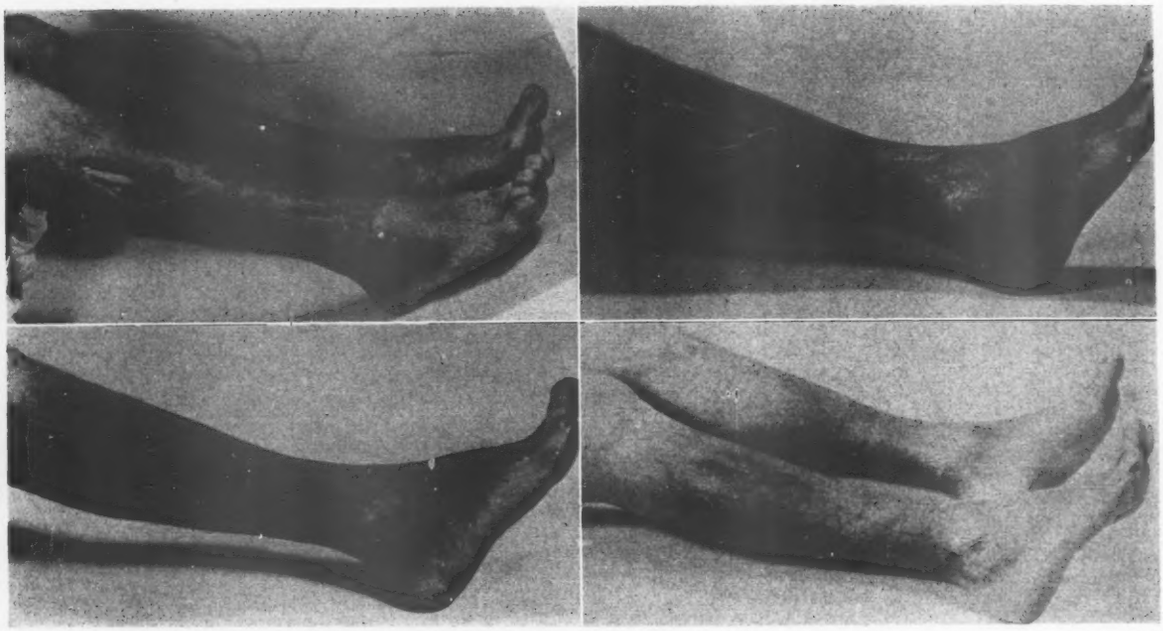
Case	Primary Diagnosis	Complications	Initial Treatment			Duration of Subsequent Treatment with Panafil	Results
			Type	Duration	Results		
13	Paralysis agitans	Huge decubitus ulcers of sacrum, both greater trochanters, both heels and both elbows	Protective padding, tryptar dressings and extensive nursing care	38 days	Temporary improvement followed by repeated breakdown	3 wk.	Autocontrols appeared desirable: panafil ointment used only on lesions to right of midline while previous treatment continued on left side; after 3 wk. of this regimen, healing under panafil ointment notably more advanced but patient died suddenly at end of that time
14	Chronic ulcerative colitis	Infection in upper left arm at site of injection for allergy tests, followed by chronic cellulitis and multilocular abscesses of both lower legs	Incision and drainage followed by bedrest, mechanical débridement and treatment with hydrogen peroxide and bacitracin ointment	80 days	Healing of infected area of right leg was slow but complete; severe butterfly ulceration of left leg healed temporarily about 10 days after interruption of treatment but recurred about 4 wk. later with such severity that amputation of leg was seriously considered	Approx. 45 days	Complete healing, with no evidence of recurrence at 3 mo. follow-up examination
15	Diabetes mellitus	Heavy calluses on plantar surfaces of right large toe and tip of middle toe; coronary occlusion	Surgical débridement	Repeated over a period of several yr.	Periodic healing but repeated infection requiring extensive management	5 days	Complete separation of calluses without infection or ulceration of underlying skin
16	Paraplegia	Chronic, indolent sacrococcygeal decubitus ulcer	Frequent dressings with variety of ointments, protective medications, protective devices and constant nursing care	Several mo.	Occasional temporary improvement with inevitable recurrence	3 wk. following initial surgical débridement	Complete healing with newly formed, soft, elastic skin without usual scarring
17	Paralysis agitans; personality disturbance; generalized arthritis	Ulceration of mid-anterior portion of right middle finger with macerating infection and severe swelling	Warm saline soaks and applications of varidase	2 to 3 wk.	No improvement	24 days	Ulceration practically healed, swelling reduced and severe infection completely subsided
18	Carcinoma of left lingual tonsil	Local recurrence and distant metastases several months following radical neck dissection	Minimal doses of radiation to recurring 7 cm. tumor mass	3 wk.	Extensive ulceration with severe hemorrhages and drainage of malodorous purulent material	1 wk.	Prompt and obvious initial débridement with full control of offensive odor; patient died of extensive metastases shortly thereafter
19	Chronic ulcers of left lower leg	.....	Massive saline soaks, systemic antibiotics, varidase and bacitracin ointments followed ultimately by paste boot and complete bed rest	6 wk.	After 2 wk. of bedrest, most inferior of ulcers had filled in partially but two large ones in mid-portion of left leg remained entirely unhealed	3 wk.	Complete healing
20	Varicose veins, bilateral	Large varicose ulcer over lateral aspect of right ankle	Dry dressings with variety of ointments	4 wk.	No improvement	32 days (twice daily)	Complete healing
21	Cerebral hemorrhage, complete aphasia and residual weakness of right arm and leg	Gangrene of left small toe	Surgical débridement followed by hot wet dressings and varidase jelly	3 wk.	Slight improvement	17 days	Complete healing

TABLE 1 (*Continued*)

SUMMARY OF RESULTS OF TREATMENT WITH PANAFIL OINTMENT

Case	Primary Diagnosis	Complications	Initial Treatment			Duration of Subsequent Treatment with Panafil	Results
			Type	Duration	Results		
22	Buerger's disease	Ulceration on plantar surface of right big toe; ingrown toe nail of left big toe	Left-sided sympathectomy and partial excision of toe nail of left big toe; panafil ointment for ulceration of right big toe	3 wk.	No improvement in condition of left big toe; partial amputation of this member necessary; ulceration of right big toe clean but did not heal	3 wk.	Problem mitigated to great extent by panafil ointment, but healing not accomplished in either area because of underlying vascular disease; although marked improvement in both areas, advancement of vascular disorder will require additional sympathectomy on right side
23	Malignant melanoma, primary site undetermined	Multiple metastatic tumors of groin and scalp with fungating doughnut-like ulceration of latter associated with foul drainage and hemorrhage	Usual massive dressings with variety of ointments	Several wk.	Poor; increasing severity of hemorrhage with each dressing change	5 wk.	Offensive odor disappeared, effective débridement achieved, hemorrhagic tendency controlled; management of dressings greatly simplified but no apparent healing, or can any be expected
24	Paraplegia	Severe decubitus ulcer in right gluteal fold	.....	.....	.....	4 wk.	Patient discharged from hospital with a clean wound almost completely healed
25	Paraplegia	Decubitus ulcer of right buttock	Varidase jelly, tub baths, massive wet dressings	4 to 5 wk.	No improvement	2 wk.	Adequate débridement and complete healing; subsequently healed area broke down as result of chemical irritation with witch hazel; panafil ointment treatment reinstituted and firm healing again achieved in just over 3 wk.
26	Diabetes mellitus	Chronic indolent ulcers of plantar surfaces of both feet with necrotic involvement of head of third metatarsal of left foot	Variety and combination of commercial preparations of ointments and salves	2½ yr.	No improvement	4 wk.	Complete débridement of both areas with full healing on right and residual small fistulous tract on left; drainage from latter minimal
27	Infected pilonidal cyst, severe	Multiple fistulous tracts with marked foul drainage	Pilonidal cystectomy with open packing	14 days	Slow healing, large incisional cavity with foul discharge despite frequent Sitz baths	5 wk. (twice weekly for 2 wk., then daily during last 3 wk.)	Complete healing with total elimination of any disability after second week of treatment

results were most unlikely, as in instances of heavy callus of the toes or feet in diabetic patients, the material was applied without hesitation. In many patients with bilateral lesions the ointment was used on one side and a variety of other treatments were applied to the other, until it became evident beyond any doubt that the papain-urea-chlorophyllin ointment was better or at least as effective as the alternative medication. Time and cost studies were made in a number of instances with particularly impressive findings demonstrating a dramatic saving of nursing time and a very substantial decrease in cost of medication, dressings and equipment. This particular phase of the study was conducted in greater detail in another hospital during the period of this investigation and is the subject of a separate report [*21*]. It need only be mentioned here that the savings were extremely significant and compatible with the patient's greatest welfare. The sum total of results among the twenty-seven patients, whose case reports follow, are evaluated conservatively as improved, but in many instances a more enthusiastic appraisal is fully justified. Parallel studies



1A 1B 1C 1D

FIG. 1. CASE 1. A, diabetic ulceration with cellulitis. B, unhealed drainage wounds after streptococcus infection, before treatment with panafil. C, drainage wounds after eighteen days' treatment with panafil. D, healed drainage wounds after thirty-four days' treatment with panafil.

over the same period of time were conducted by Miller [22] and Morrison and Casali [23], and although these investigators were concerned primarily with the problem of decubitus ulcers their results were as encouraging as these and support a strong recommendation for more widespread use and continued assay of this useful therapeutic agent.

CASE REPORTS

CASE 1. The patient, a sixty-three year old white man with diabetes, suffered a severe streptococcus infection of the right leg which was treated with many incisions during a previous admission. (Fig. 1A.) The infection was controlled but two incisions in the lateral surface of the calf remained unhealed after a period of three months, during which he was treated with bedrest, ace bandage, antibiotic ointments and non-specific irrigations. (Fig. 1B.) He was readmitted at the end of that time for skin grafting of these unhealed areas but asked to have a hernia repaired prior to the grafting. During the pre- and postoperative period he had daily dressings with panafil ointment. A cornified overgrowth of tissue at the margins of the skin ulcers separated after two days of treatment, following which the wounds went on to heal uneventfully after approximately one month. The healed areas were re-epithelized with soft, elastic, new skin and the patient was discharged without further event. (Figs. 1C and 1D.)

CASE 2. This patient was a thirty-two year old white man with severe diabetes who had only a very poor understanding of diabetic care. A callus formed in the skin on the plantar surface of the first phalanx of the left big toe which became severely infected and continued to drain purulent material even after apparently adequate surgical débridement. Treatment with panafil was instituted and within two weeks the callus had separated and the underlying tissue appeared clean and healthy, healing down to a small residual sinus. This was then widely excised and a split-thickness graft applied. The graft healed slowly but was crusted over with amorphous, granular material. Panafil was again applied and after several days the crust could be lifted off entirely. Beneath this the graft was found to be clean and the wound remained completely covered with viable skin.

CASE 3. A sixty-nine year old white man was admitted with a history of having suffered multiple wounds and abrasions of the skin of both ankles five months previously. These resulted from contact with brambles and thorns of bushes through which he ran in an open field attempting to escape a swarm of wasps. With inadequate self-treatment these areas became severely infected and ulcerated. On two separate occasions he was hospitalized for surgical débridement and treatment with a wide variety of drugs and technics, none of which produced more than very temporary improvement. Upon admission to the East Orange Veterans Administration Hospital the skin in the pretibial area

in the lower two-thirds of the right leg was gangrenous and circulation in the right foot was definitely impaired. Although amputation was deemed inevitable, he was treated with panafil ointment dressings initially and after three days the entire gangrenous area was "lifted" from the underlying viable tissue and, although the tibia was exposed in this area, the fascia and muscle appeared remarkably clean. However, the distal circulation became obviously and progressively inadequate and subsequent amputation above the knee was performed with no further incident.

Case 4. This sixty-six year old white man was under treatment for severe generalized arthritis and an undiagnosed neurological disease. Shortly after his admission a reddened, inflammatory and necrotic lesion was noted in the middle portion of his back. This appeared to be a typical pressure change but was situated in an area of the back where there was no pressure. Although the central portion of this area was moderately fluctuant, an incision produced only a few drops of purulent material. Panafil ointment was applied and within seventy-two hours the mass liquefied and drained satisfactorily through the incisional wound. Complete healing followed within one week. A similar lesion developed between the left greater trochanter and iliac crest, again in an area where there was no pressure, and panafil ointment controlled the process promptly with adequate healing within several days.

Case 5. This sixty-four year old white man with generalized arteriosclerosis had undergone left lumbar sympathectomy, and split-thickness skin grafts were used to cover gangrenous defects in the skin of the left foot. These treatments were very successful but he was admitted subsequently to the East Orange V.A. Hospital for treatment of infection and patchy gangrene of the toes and dorsum of the right foot. Panafil ointment was applied and the gangrenous areas were débrided promptly within seventy-two hours. However, the circulation of the foot was severely impaired and saving it was deemed impossible. Amputation below the knee was performed and the stump healed well, but postoperatively on two occasions the patient fell; once in the bathroom and once at bedside, and both times his stump was severely traumatized, with redness, swelling and tenderness developing promptly, complicated further by a quarter-sized ulceration of the skin overlying the tibial stump. This was treated with panafil ointment locally and warm wet dressings to the swollen areas proximal to the ulceration. The ulceration was débrided within forty-eight hours and healed within a week. The redness, swelling and tenderness of the remainder of the stump subsided promptly and reamputation became unnecessary.

Case 6. This thirty-one year old Negro man, a paraplegic, had severe decubitus ulcers of the sacrum, right hip and right thigh posteriorly. He was treated with the usual conventional measures including whirlpool baths, antibiotic ointments, appliances for the relief of pressure and high protein and high vitamin diets, all to little avail. Treatment with panafil ointment was then initiated. Within twenty-three days the sacral decubitus ulcer was healed and there was marked improvement in the condition of the hip. This latter lesion was severely undermined and the healing was delayed, but it ultimately closed in about sixty days and no surgical intervention was necessary.

Case 7. A sixty-four year old white man was admitted for treatment of diabetic gangrene of the toes of the right foot. Surgical débridement was unsuccessful and transmetatarsal amputation was performed. Two weeks thereafter extensive necrosis of the skin flaps developed, with a rapidly spreading cellulitis in the operative area. For the next two weeks he was treated with panafil ointment dressings and periodic mechanical débridement with notable improvement in the local area. However, infection spread proximally to the knee as a consequence of progressive arterial occlusion and amputation above the knee was performed.

Case 8. This fifty-three year old Negro man had a long history of epilepsy. His hospital treatment was complicated by the development of large, deep, extremely foul decubitus ulcers of the right greater trochanter and sacrum. There was extensive purulent drainage and the offensive odor was so severe as to interfere with nursing care. Treatment with panafil ointment was begun and dressings were changed twice daily. The offensive odor was controlled promptly and within thirty days the decubitus ulcers had been débrided, with healthy appearing underlying tissue. Full nursing care was again possible and at the time of this report the ulceration of the sacrum is practically healed, while that of the greater trochanter, although quite clean, may still require skin flap closure.

Case 9. A twenty-eight year old white man, a quadraplegic, had a huge decubitus ulcer over the right trochanteric area. Treatment with panafil ointment was initiated and within one month healing was practically complete, with only a small residual sinus tract.

Case 10. This sixty-five year old white man with chronic, severe, generalized arthritis had an ulcer of the left heel. There was no evidence of peripheral vascular disease and there were no

varicosities. This was treated initially with hot wet dressings, a variety of ointments and varidase® jelly, all without effect. Panafil ointment was instituted under a protective heel dressing and improvement was noted within several days. Healing was complete within three weeks and at a four-month follow-up there was no evidence of recurrence of ulceration.

CASE 11. This fifty-eight year old white man had burned the palmar and extensor surfaces of the four fingers of his left hand. He was treated by his local physician with vaseline gauze dressings, "healing" ointments and "sedative" ointments. After several weeks it became apparent that this treatment was ineffective. Examination upon admission to the East Orange V.A. Hospital revealed that these fingers were badly infected and treatment with panafil ointment was instituted in an effort to secure rapid débridement, following which skin grafting was contemplated. Within ten days improvement was so marked and re-epithelization so advanced that the plan for skin grafting was abandoned. Within three weeks healing was practically complete with no residual complications.

CASE 12. This thirty-five year old Negro man was brought to the East Orange V.A. Hospital with chronic, brawny lymphedema of both legs of unknown etiology, complicated by small ulcerations of both legs and elbows. The lymphedema responded promptly to bedrest and the ulcerations were completely healed after two weeks' treatment with panafil ointment.

CASE 13. The patient, a sixty-two year old Negro man, was transferred from another hospital with a diagnosis of paralysis agitans, complicated by huge decubitus ulcers over the sacrum, both greater trochanters, both heels and both elbows. He had been treated intensively with tryptar® dressings, protective padding to the involved areas and extensive nursing care for thirty-eight days. The daily cost of the tryptar alone was $28. Inasmuch as this patient had bilateral lesions, it was decided to observe comparative tests with panafil ointment. Consequently, treatment with tryptar ointment was continued on the lesions on the left of the midline, while panafil was applied to those on the right. After three weeks of treatment healing was notably proceeding more rapidly on the right side, but the patient died suddenly shortly thereafter of no discernible cause.

CASE 14. This twenty-nine year old white man had severe ulcerative colitis; an infection developed at the site of injection for allergy tests in the left arm. This area was markedly resistant to treatment but ultimately healed. Shortly thereafter abscesses of the lower third of the right leg anteriorly and the upper third of the left leg anteriorly appeared together with marked swelling of the ankles. These abscesses were drained and the area on the right leg healed slowly but completely. In the left leg a marked butterfly ulceration developed which did not respond to usual measures, including bedrest, débridement, hydrogen peroxide dressings and bacitracin. After the initial culture, which was positive for Staphylococcus aureus, all subsequent cultures were reported sterile. However, the ulceration spread slowly and became undermined with irregular, reddened, raised margins. (Fig. 2A.) The base was covered with foul, necrotic, grayish yellow, thick purulent material and, even when bacitracin was given systemically, there was no halt to the spread. Periodically, pockets of purulent material opened and discharged, and the necessary extensive nursing care combined with the extremely high cost of medication soon became a severe problem. In addition, the enforced bedrest was very trying to the patient since his colitis was active during this two and a half-month period and the control of his diarrhea was extremely difficult. At the end of approximately eighty days the ulcer appeared clean at last and it was decided to pinch graft the area. However, he signed out of the hospital against medical advice and announced that he would apply his own dressings at home at his own convenience. Within six weeks he returned, stating that the area had healed after about ten days at home but became infected again two weeks prior to this admission. At the time of admission this infection was so severe that loss of his leg was considered a strong possibility. The fluctuant areas were unroofed by multiple incisions and culture of the recovered material was again positive for Staph. aureus sensitive to bacitracin. For several days postoperatively panafil ointment, to which bacitracin was added, was applied twice daily with marked prompt improvement. (Fig. 2B.) Thereafter, treatment was continued with panafil ointment alone. After three weeks the patient was allowed out of bed and his subsequent management was on a completely ambulatory basis. He was given weekend passes during which time he applied the ointment once daily at home, and after two weeks more he was given an extensive leave from the hospital, returning once weekly for follow-up. Healing proceeded at a rapid rate without pain or discomfort, other than a moderate stinging when fresh ointment was first applied. This lasted only for several minutes and at no time was the patient inclined to abandon the treatment because of this discomfort. A biopsy taken at the healing edge showed very satisfactory epithelization with a full layer of squamous cell epithelium. There was no further complication and complete healing with soft, elastic skin with its sensitivity intact was

2A 2B 2C

FIG. 2. Case 14. A, severe necrotizing infection (Staph. aureus). B, early adequate débridement after eight days' treatment with panafil ointment. C, complete healing after forty-five days.

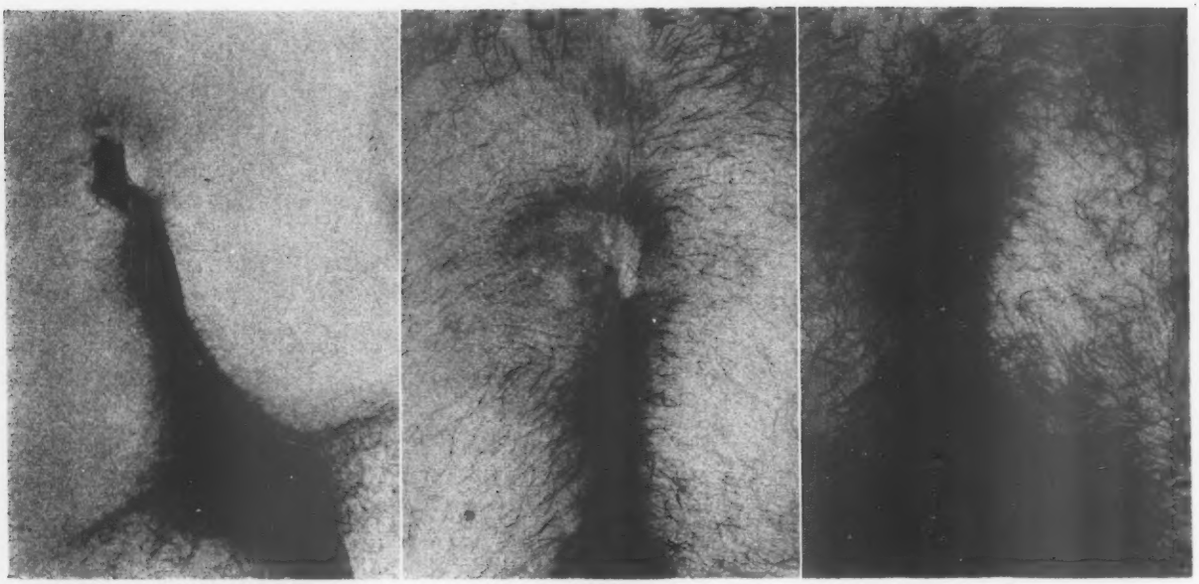
completed in about forty-five days. (Fig. 2C.) At the time of this report a recent follow-up indicates there has been no further breakdown of the skin or recurrence of infection.

CASE 15. A forty-two year old white man, who was a severe diabetic, had repeated formations of heavy calluses on the plantar surface of the right large toe and the dorsal surface of the tip of the middle toe. These had been débrided surgically several times previously but required long periods for full healing; occasionally complicating infection was a decided threat. He was admitted to the East Orange V.A. Hospital for treatment of a second coronary occlusion. This required complete bedrest and during this time it was decided to treat his calluses with panafil ointment. Within three days of institution of treatment, these calluses separated partially, this process being completed after an additional forty-eight hours. Although it is expected that callus will form again, the treatment with the panafil ointment was obviously much more satisfactory than surgical management.

CASE 16. A twenty-one year old white man, a paraplegic, was admitted to the East Orange V.A. Hospital for rehabilitation. During this period a chronic, indolent sacrococcygeal decubitus ulcer developed. (Fig. 3A.) This was extremely refractory to all of the usual treatments, many of which were extremely expensive, and valuable time was being lost from other measures necessary for his rehabilitation. It was finally decided to débride this ulcer surgically, following which panafil ointment was applied once daily. Within two weeks the area was entirely healed, except for a small medial residual ulceration. (Fig. 3B.) Within three weeks healing was complete (Fig. 3C) and the newly formed skin in no way resembled the usual scar but was soft, supple, pliable and has remained resistant to further breakdown.

CASE 17. A sixty-four year old white man with severe paralysis agitans, personality disturbances and generalized arthritis with moderate spasm and fixation of joints was admitted with an ulceration of the mid-anterior portion of the right middle finger, associated with a macerating infection and severe swelling. This was a result of trauma by his own thumbnail during severe spastic seizures. Warm saline soaks as well as applications of varidase produced no improvement. Panafil ointment in daily dressings was then started, and after twenty-four days the ulceration was almost completely healed, the swelling entirely reduced and the severe infection had disappeared. At the time of discharge from the hospital, the patient had no further distress referable to this complication.

CASE 18. This sixty-six year old white man had undergone left radical neck dissection, followed by large doses of radiotherapy, for left lingual tonsillar carcinoma. He was discharged in relatively good condition but was readmitted several months later



3A 3B 3C

FIG. 3. Case 16. A, decubitus ulcer, coccygeal area, before panafil therapy. B, decubitus ulcer after fourteen days' treatment with panafil. C, complete healing after forty-eight days of treatment.

because of local recurrence and distant metastases. There was a 7 cm. fixed tumor mass in the left side of the neck in the area of the previous operative scar. For the next three weeks he was given a course of minimal doses of radiation, during which time the tumor ulcerated extensively and became extremely malodorous. It was not possible to attempt mechanical débridement and ordinary bland surgical dressings were completely ineffective. Panafil ointment dressings were then employed for one week and there was prompt and obvious initial débriding action with full control of the offensive odor. However, with the extension of the malignant process, severe hemorrhages occurred with each dressing and the patient died of his carcinoma shortly thereafter.

CASE 19. A thirty-two year old white man was hospitalized for disabling chronic ulcers of the left lower leg which he claimed to have incurred as a result of being wounded with "wooden bullets" during the Normandy invasion. Initially he was treated with massive saline soaks, systemic antibiotics, varidase and bacitracin, all with no improvement. It was soon suspected that he was retarding the healing of these wounds by self-inflicted trauma; a paste boot was applied up to the knee and the patient was placed on complete bedrest. After two weeks the most inferior of the ulcers had partially filled in but two larger ones in the mid-portion of the left leg remained entirely unhealed. Panafil ointment was then instituted once daily and healing was complete within three weeks.

CASE 20. A sixty-five year old white man was admitted for treatment of a large varicose ulcer of the lateral aspect of the right ankle. (Fig. 4A.) This had followed severe trauma when the patient struck his ankle as he slipped from a stepladder. The ulcer extended through all layers of the skin, its base being covered with an inflammatory, serosanguineous exudate. He refused surgery for ligation of his varicosities but remained in the hospital for treatment of a high rectal tumor which was subsequently removed via an abdominal approach. During the period of this treatment panafil ointment dressings were applied to the skin ulcer twice daily with prompt improvement within two weeks (Fig. 4B) and complete healing within thirty-two days. (Fig. 4C.) Healing was obviously by re-epithelization which produced a soft, elastic, nontender skin covering. By the time of discharge one week later the healed area was already blending inconspicuously with the surrounding normal skin color and texture. (Fig. 4D.) Except for partial bedrest for the first several days postoperatively, this patient was entirely ambulatory during his hospital stay.

CASE 21. This sixty-nine year old white man, who had complete aphasia and residual weakness of right arm and leg following a cerebral hemorrhage, was admitted for treatment of an infected, gangrenous left small toe. This was débrided surgically but continued to remain moderately infected and improved only slightly with hot wet dressings and varidase jelly. Panafil ointment was then applied in daily dressings, and after several days adequate

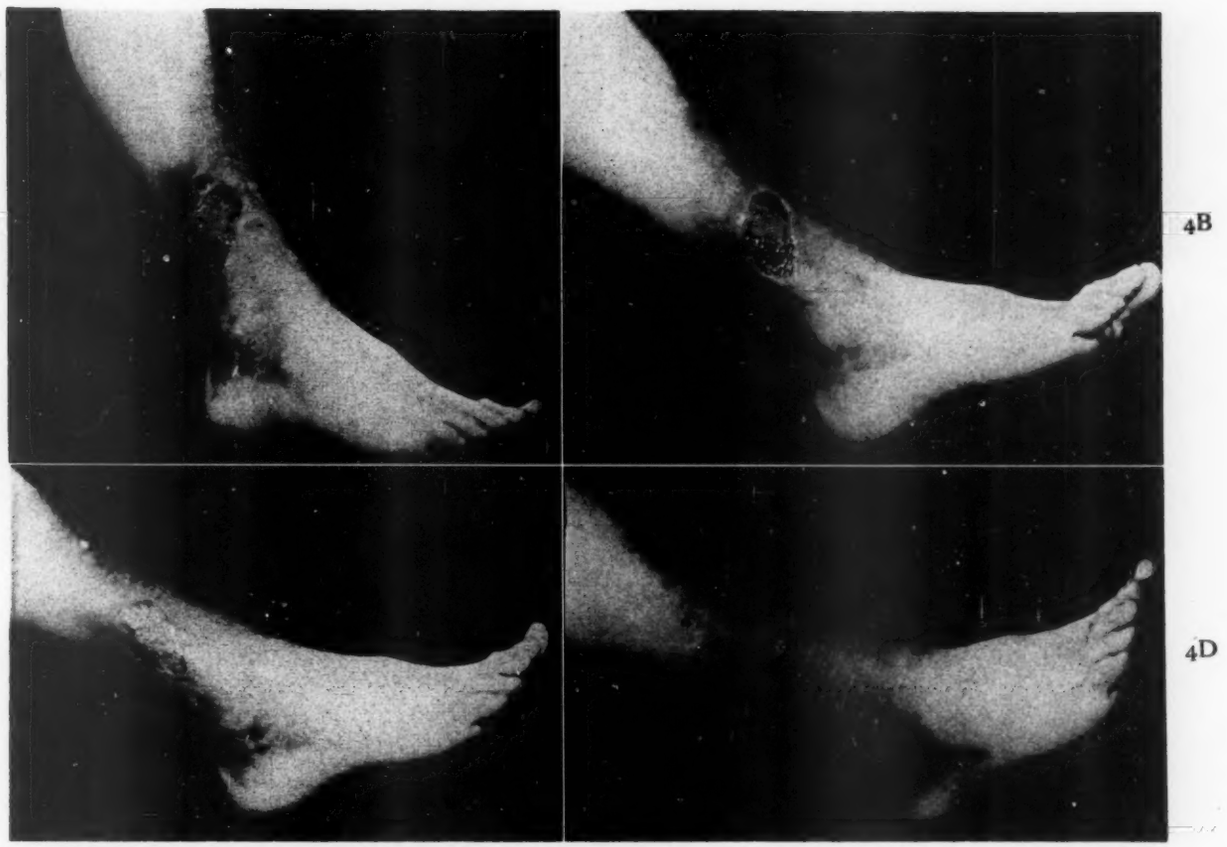
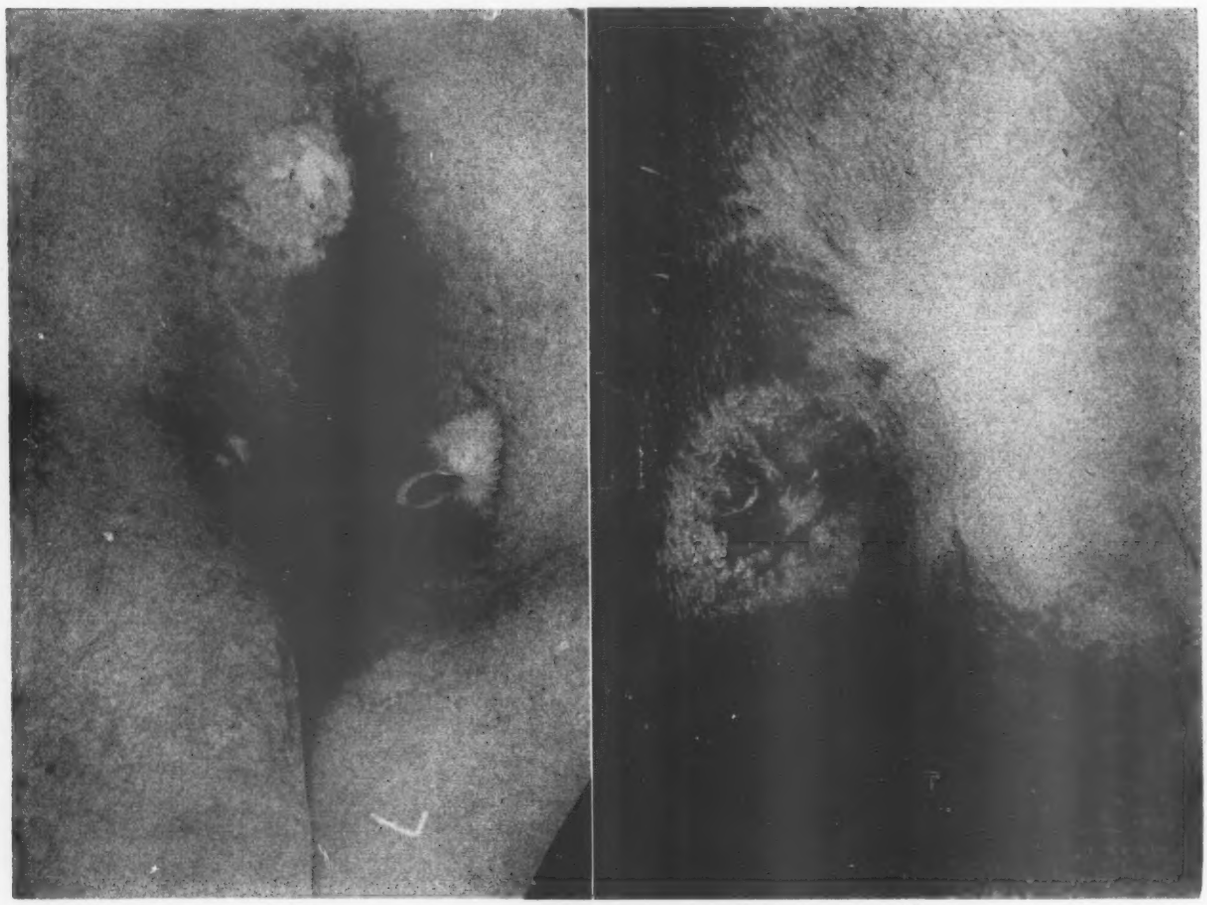


FIG. 4. Case 20. A, varicose ulcer, right leg, after 1 day of treatment with panafil. B, after fourteen days' treatment with panafil. C, third day after cessation of panafil ointment (thirty-two days of treatment). D, ninth day following cessation of panafil ointment.

débridement occurred to the degree that a fragment of phalangeal bone could be identified in the depths of the wound. This was excised and the skin edges loosely approximated. Healing progressed at a very slow rate and drainage persisted for approximately ten days. A heavy encrustation then formed and the drainage ceased. It was decided to refrain from interfering with this surgically, and panafil ointment was continued instead. In three days the crust lifted off with great ease and the underlying tissue was found to be clean and granulating. Within another four days the area was completely healed.

CASE 22. A thirty-six year old white man with advanced Buerger's disease, complicated by all the physical and psychological problems of the disorder, was admitted for treatment of an ulceration on the plantar surface of the right big toe and for resection of an ingrown toe nail of the left big toe. Following left-sided sympathectomy the left toe nail was partially excised; during this time the ulceration of the right big toe was treated with panafil ointment with excellent débridement but little progress in healing. The left toe did not respond well to its initial treatment and it became necessary to remove the remainder of the nail. However, with continued pain it was necessary to go a step further and perform partial amputation of the toe. The suture line broke down and progress of the disease in this toe advanced proximally, but the patient refused further surgical therapy. Panafil ointment applied in this area maintained a clean wound but complete healing did not take place because of the underlying vascular disease. In this case it can be said that the problem was mitigated to a great extent by treatment with panafil ointment, but total solution of the situation was clearly impossible from the very beginning.

CASE 23. This thirty-four year old Negro man had malignant melanoma of undetermined primary site and multiple metastatic tumors of groin and scalp. Foul, fungating, doughnut-shaped ulcerations covering an area 6 cm. in diameter developed in the skin overlying the right parieto-occipital region of the scalp. These tended to hemorrhage easily on slightest contact and oozed serosanguineous fluid continuously. There was one large necrotic center encircled by peripheral encrustations with an over-



5A 5B

FIG. 5. Case 25. A, decubitus ulcer, right ischium, before treatment with panafil. B, fourteen days after treatment with panafil.

whelming offensive odor. For several weeks ordinary dressings were extremely difficult to manage because they promptly became intimately adherent in the depths of the ulcers and each dressing change was attended by severe hemorrhage. Panafil ointment was instituted when this complication became severe; subsequent dressings were simplified, the hemorrhagic tendency was well controlled, the offensive odor disappeared and effective débridement was achieved, although in this hopeless situation no healing was expected.

CASE 24. The patient was a twenty year old white man, a paraplegic, in whom a severe decubitus ulcer developed in the right gluteal fold overlying the right ischial spine. Panafil ointment therapy with daily dressings was instituted, and within four weeks the patient was able to leave the hospital with a clean wound almost completely healed.

CASE 25. The patient was a thirty-four year old Negro man, a paraplegic, in whom a decubitus ulcer of the buttock overlying the right ischium developed. He was treated initially with varidase jelly, tub baths twice daily and repeated massive wet dressings, all without improvement. (Fig. 5A.) Therapy with panafil ointment was instituted and within two weeks the ulcer was completely débrided and healed. (Fig. 5B.) Subsequently the patient treated severe hemorrhoids injudiciously with witch hazel compresses and the delicate new skin covering the decubitus ulcers broke down as a result of the continuous chemical irritation. Panafil ointment was applied again and in just over three weeks the area was once more healed firmly.

CASE 26. This sixty-three year old diabetic white woman, with chronic indolent ulcers of the plantar surfaces of both feet in the area just proximal to and between the second and third toes, had been treated for many months with a variety and combination of commercial preparations of ointments and "salves" without success. In the left foot the infection ultimately involved the head of the third metatarsal; this soon disappeared as a

result of the osteolytic process. She had been advised to consider an intermalleolar amputation and was referred to one of us (T. G.) for the necessary surgery. At the time of her first office visit her diabetes was controlled but there was marked seropurulent drainage from the ulcerated and fistulous opening of the lesion on the left, surrounded by a firm raised callus 3 cm. in diameter. On the right there was a similar smaller callus which appeared chronically infected but which was not draining at that time. Metatarsal bars were ordered for both shoes and the pain and discomfort in both feet was promptly relieved. Drainage on the left diminished and the callus on the right disappeared within two weeks. However, these difficulties reappeared several months later following injudicious paring of the calluses by a local chiropodist, and both areas were obviously chronically infected. Panafil ointment dressings were instituted and complete débridement was achieved within four weeks. When last seen the fistulous tract in the left foot was reduced to a small slit with no discharge and the surrounding skin was soft and pliable, while on the right there was no further evidence of difficulty.

CASE 27. This seventeen year old white boy had a three-year history of foul, periodically painful and continuously draining pilonidal cyst with multiple midline and bilateral fistulous tracts; he was hospitalized for cystectomy. As a result of his extensive disease, the necessary wide excision, which was packed open, was considerably more extensive than usual and it was expected that his healing would be delayed a number of months. He was discharged from the hospital in four days and within ten days a solid layer of granulation tissue lined the depths of the large cavity. This soon became exceedingly foul, and panafil ointment was applied twice weekly for two weeks with prompt deodorization and remarkably rapid granulation and filling in of the cavity. At the end of that period it was possible for the patient's mother to apply daily dressings, and three weeks thereafter (a total of six and a half weeks postoperatively) this cavity was completely healed. After the second week of treatment the patient was in no way disabled and was able to carry on full, unrestricted activity.

SUMMARY AND CONCLUSIONS

The pertinent antecedent literature and background regarding the subject of enzymatic débridement of wounds and ulcers is reviewed and specific criteria governing the basic effectiveness of a suitable agent are expressed.

A preparation of papain-urea-chlorophyllin ointment, specifically elaborated to fulfill the requirements of these criteria, has been utilized in twenty-seven cases over a period of eight months. These embraced a variety of problems and the results achieved in all but one instance support the established effectiveness of this preparation. In addition, the objectives of simplicity of treatment and practical economy, which are often inadvertently ignored, have been satisfied unquestionably in every case.

Papain, in combination with urea, is very definitely an effective débriding agent, and the addition of chlorophyllin demonstrably increases the tolerance of surrounding tissues to the products of cellular digestion, producing an environment facilitating accelerated healing by true physiologic processes. In no instance was the use of this ointment attended by any notably unfavorable reaction and its demonstrated stability, safety and versatility, together with its favorable effects, invites further use on a broad scale, for the hospital patient as well as the ambulatory case, whenever conservative débridement is a problem of accomplishment.

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Secondary Amyloidosis in Injuries to the Spinal Cord

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The occurrence of amyloid disease in patients with chronic injury to the spinal cord had received only scanty mention in the literature up to the time of the Veterans Administration Conference on Paraplegia in 1954 [2,6,10,11,13].

At that conference reports from the various centers revealed that there was an incidence of 1 per cent [1,4,5,7,9,11]. Whereas at the West Coast Center at that time ten patients of 1,000 having traumatic lesions (1 per cent) had been diagnosed either clinically or at necropsy as having amyloidosis [4,5], twenty-one of 1,200 patients (1.75 per cent) had been diagnosed up to August, 1957. Thirteen of the twenty-one patients were deceased and eight were still alive at the time of this writing.

Amyloidosis is a metabolic disease characterized by the deposition of abnormal protein in body tissue [3]. There are two forms of the disease [3,11]. The most common form is typical or secondary amyloidosis which is found in such chronic diseases as tuberculosis, empyema, lung abscess and osteomyelitis. Occasionally it is found associated with carcinoma, myeloma and Hodgkin's disease. Secondary amyloidosis shows a predilection for the spleen, liver, kidney, adrenal glands and lymph nodes. The pancreas and intestinal tract have been found to contain amyloid material [12]. Although no organic system is spared, the central nervous system is seldom affected. Primary or atypical amyloid disease is seen without any other associated disease. The amyloid deposition in primary amyloid disease is essentially in the blood vessels and immediately surrounding tissues. Deposits may be focal in the body occurring in the tongue, thyroid, heart, lung, etc., or there may be widespread involvement of the arterioles.

Early diagnosis of amyloidosis is dependent upon an awareness of the disease entity. Manifestations of the disease are usually influenced by the organ or system affected [3]. Albuminuria is usually the first sign, gradually increasing to as much as 12 gm. and more per twenty-four hours. Frequent examination of the abdomen will eventually reveal hepatomegaly and/or splenomegaly. The diagnosis usually becomes self-evident when the following signs, either singly or in combination, are found, namely, emaciation, anasarca, abnormal serum globulins, anemia, hypoproteinemia, elevated blood cholesterol, and renal and/or adrenal failure. The presence of globulin in the urine (associated with hepatomegaly and splenomegaly) is pathognomonic according to Kurnick [8]. Hypertension is rare as is jaundice. Liver function tests are usually normal.

The Congo red absorption test can be of value in detecting amyloidosis. Interpretations are based on the great affinity of amyloid substance for Congo red. It should be remembered that in the presence of marked albuminuria, a fair amount of dye can be lost in the urine and this should be measured. When the one-hour specimen reveals a 60 per cent loss of the dye from the serum, amyloidosis may be suspected. However, 90 per cent or more absorption is unequivocally positive.

Biopsy can be helpful in making a diagnosis. Open technics such as of the skin, lymph nodes, tongue and lips are relatively safe procedures. Needle biopsies of internal organs in paraplegics should be condemned because of (1) the friability of these organs if amyloid is present and (2) the poor coagulation of blood which

is present in many patients with pyelonephritis. When operating upon a kidney for a specific purpose, e.g., calculi, a biopsy can be performed.

Obviously, we are dealing with secondary amyloidosis in patients with injuries to the spinal cord since the principal cause is the chronic decubitus ulcer with its accompanying bony involvement.

The increase of incidence at the West Coast Center from 1.0 to 1.75 per cent is due to an awareness rather than an actual increase of the disease. The incidence is probably 2 per cent or more since we have not had autopsy reports on patients dying elsewhere than at paraplegia centers or those who are being currently cared for by private physicians and whose cases are not reported to us.

The examiner must depend in many instances upon clinical findings and history rather than upon the Congo red test results. Congo red tests have repeatedly shown absorption below 60 per cent in patients suspected of amyloidosis, yet the autopsy verified the clinical impression. This is exemplified by a patient with a chronically draining osteomyelitis of the spine and decubitus ulcers so severe as to require bilateral exarticulations at the hip joints, yet dye retention of only 37 per cent was found after forty-three months of continuous drainage from the spine.

All twenty-one patients diagnosed at the West Coast Center had histories of chronic bedsores. It is interesting to note that one patient with an unequivocal diagnosis of amyloidosis is still alive nearly four years later. Longevity among these patients appears to be proportionate to "kidney reserve," for the "fast deaths" appear to be in patients with fulminating uremia. Although the literature discloses that in large series of necropsies in patients without spinal cord lesions but with chronic pyelonephritis, amyloidosis has not been found, our series presented herein contains two cases which suggest that the chronicity and severity of the pyelonephritis in itself may have caused the secondary amyloidosis. One patient who had had decubitus ulcers closed surgically in 1947 and had no recurrence died of uremia ten years later with amyloidosis found at autopsy. However, many paraplegics at one time or another have decubitus ulcers and, therefore, pyelonephritis as the sole cause of secondary amyloidosis will only be proved or disproved if found in a paraplegic with pyelonephritis but without history or evidence of decubitus ulcer.

The chief cause of amyloidosis in patients with injury to the spinal cord remains the decubitus ulcer with its accompanying involvement of bone, while pyelonephritis plays only a secondary role.

Various treatments have been offered but none has been a panacea. Prevention of decubitus ulcers is the only answer.

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A Study of Operations upon the Gallbladder and Common Bile Duct

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EXCLUDING appendicitis and hernia, the most common cause for abdominal exploration is disease of the gallbladder and extrahepatic bile ducts. In the opinion of most good surgeons no operative procedure, certainly abdominal, at least, requires greater skill and judgment than that performed upon these structures. A great many patients present themselves when the degenerative diseases, particularly of the cardiovascular system, have become manifest and when the end result of a diet rich in fats and carbohydrates is all too apparent.

TABLE I
PATHOLOGY IN 556 PATIENTS, 506 CHOLECYSTECTOMIES

Stones	456
Acute cholecystitis	133
Chronic cholecystitis	34
Cancer	6
Cystic duct remnant	6
Gall bladder remnant	1
No lesion	2

A study has been made of operations upon the gallbladder and common duct at the North Carolina Baptist and City Memorial Hospitals in Winston-Salem, North Carolina for the years 1953 to 1955. The total comprised 556 patients, both service and private. No attempt has been made to separate or compare them as groups. These operations were performed by twenty-five different surgeons and residents.

Table I shows the pathology in 506 cholecystectomies. In 93 per cent of the cases there were stones in the gallbladder. This figure includes both the acute and non-acute cases. There were thirty-four cases in which a diagnosis was made of chronic cholecystitis only, no stones being found. There were 133 patients with an acute condition of the gallbladder. This includes both those with acute and subacute conditions of the gallbladder. Aside from the fluid and electrolyte imbalance and the infection found in the occasional early case, it is often technically more difficult to operate on the patient with the subacute condition than the one with the acute condition. Furthermore, in those in whom only cholecystostomy is performed, one must necessarily accept the clinical diagnosis of the surgeon. It is well known that surgeons often diagnose a gallbladder as acute when the pathologist will diagnose it as chronic. The converse happens less often.

There were six cancers of the gallbladder or 1.18 per cent. This corresponds rather closely with the figure of 1.12 per cent, as compiled by Arminski [1].

In two patients operated upon and in whom the gallbladder was removed, the diagnosis by the pathologist was "no lesion."

In the group of 556 patients, there were six with cystic duct remnants and one with gallbladder remnant.

The oldest patient operated upon was eighty-six years of age and the youngest ten. There were two patients, aged ten, both of whom had gallbladder stones in the absence of proved splenic disease or blood dyscrasia.

Of the 133 patients with acute cholecystitis, eighty-five had cholecystectomy alone. (Table II.) There were two deaths in this group for a mortality rate of 2.3 per cent. Twenty-six had cholecystostomy, with one death for a rate of 3.8 per cent. There were twenty-two in whom both cholecystectomy and choledochostomy were performed. Three died for a rate of 13.6 per cent. The mortality rate for the 133 patients was 4.51 per cent. This figure compares with 2.6 per cent reported by Glenn [4] and 1.5 per cent reported by Cattell and Warren [2]. The Mayo Clinic reports on 126 acute cases

in which surgery was performed in two years with no deaths [5,7]. Meagher and Campbell [6] reported a mortality rate of 7.9 per cent. Many of our patients traveled long distances, which may account, in part, for our higher mortality figure.

TABLE II
PROCEDURES IN ACUTE CHOLECYSTITIS

Procedure	No.	Deaths	%
Cholecystectomy alone	85	2	2.3
Cholecystectomy plus dochostomy	22	3	13.6
Cholecystostomy	26	1	3.8
Cholecystectomy (all)	107	5	4.67
Total	133	6	4.51

TABLE III
PROCEDURES IN ABSENCE OF ACUTE INFLAMMATION

Procedure	No.	Deaths	%
Cholecystectomy alone	304	1	.32
Cholecystectomy plus choledochostomy	84	2	2.38
Cholecystostomy plus choledochostomy	1	1	100.
Total	389	4	1.03

It should be noted that the highest mortality rate was in the group who had both cholecystectomy and choledochostomy, 13.6 per cent as opposed to 2.3 per cent for cholecystectomy alone. Cattell and Warren [2] report a mortality rate of 1.1 per cent for cholecystectomy and choledochostomy. This group included seventy-two patients with acute cholecystitis. Glenn [4] reports a rate of 5.3 per cent in this condition when both procedures are performed. The Mayo and Lahey Clinic figures are perhaps aided somewhat by the fact that their patients are all private.

Table III shows the mortality rate for 389 patients who had undergone surgery in the absence of acute inflammation and who had either cholecystectomy, cholecystectomy plus choledochostomy, or cholecystostomy plus choledochostomy. In cholecystectomy alone, there was one death for a rate of .32 per cent. Cholecystectomy plus choledochostomy gave a rate of 2.38 per cent, and one patient who had cholecystostomy and choledochostomy died. The mortality rate for all patients with a chronic condition undergoing cholecystectomy plus choledochostomy was 1.03 per cent.

To put it another way (Table IV), in all cholecystectomies performed, in both acute and chronic conditions, with no other procedure the rate was .51 per cent. Colcock [3] reported a rate of .9 per cent in this group of patients.

TABLE IV
MORTALITY IN CHOLECYSTECTOMY ALONE

Pathology	No.	Deaths	%
Cholecystectomy, not acute	304	1	.32
Cholecystectomy, acute	85	1	1.17
Total	389	2	.51

TABLE V
CHOLEDOCHOSTOMY

Procedure	No.	Stones	%	Deaths	%
With cholecystectomy, not acute	84	32	38	2	2.38
With cholecystectomy, acute	22	8	36	3	13.6
After cholecystectomy	25	8	32	1	4.0
With cholecystostomy	1	0	0	1	100.
Total	132	48	36.4	7	5.3

There were 132 patients who had choledochostomy. (Table v.) Of this group, which was 23 per cent of the total number of patients, stones were found in forty-eight or 36.4 per cent. It should be noted that the number of patients whose ducts were explored was less than that commonly reported. The percentage of stones found is about the average. In the chronic cases with stones, the duct was explored eighty-four times and stones were found in 38 per cent. In those with acute cholecystitis, the ducts were explored in twenty-two or 16.5 per cent and stones were found in 36 per cent of these. In those patients who had had previous cholecystectomy two weeks to twenty years before, stones were found in 32 per cent. The over-all percentage of stones found was 37.7 per cent of those ducts explored. Therefore, a total of 7.97 per cent of all cholecystectomy patients had common duct stones. The usual figures are around 10 to 11 per cent. Perhaps, if more ducts had been explored, a

TABLE VI

FACTORS CONTRIBUTING TO DEATHS

Patient	Age (yr.)	Adiposity	Pathology	Arteriosclerotic Heart Disease	Critical Time of Operation	Anesthesia	Complication	Procedure
B. K.	77	.....	Acute cholecystitis	.....	.....	.....	Wound evisceration, thrombophlebitis	Cystectomy
M. D.	69	.....	Subacute cholecystitis	Yes	.....	.....	.....	Cystostomy
J. T.	74	.....	Chronic cholecystitis with stones	Yes	.....	.....	.....	Cystostomy, dochostomy, no stones-duct
C. B.	72	Obese	Chronic cholecystitis with stones	Yes	.....	.....	.....	Cystectomy
S. R.	70	Obese	Acute cholecystitis, stone in common duct	.....	2nd operation	.....	Peritonitis	Cystectomy, dochostomy 2 times, stone 2nd
A. S.	80	.....	Acute cholecystitis, common duct stones	Yes, impaired renal function	.....	.....	.....	Cystectomy, common duct stones, through cystic
L. S.	68	Obese	Acute cholecystitis with stones, none in duct	Yes	Yes, toxic	Probably anesthetic death	.....	Cystectomy, dochostomy, no stones-duct
K. P.	77	.....	Rupture common duct due to stone, diffuse peritonitis	Yes	Yes, peritonitis	.....	.....	Cystectomy, duct drained, stones in both
R. B.	69	Obese	Chronic cholecystitis with stones	.....	.....	Aspirated vomitus on operating table	Wound eviseration, pulmonary embolus	Cystectomy, dochostomy, stones in both
L. T.	65	.....	Chronic cholecystitis with stones, none in duct	.....	.....	.....	Liver abscess, meningitis, fungus	Cystectomy, dochostomy, no stones in duct

higher percentage of the total number would have had common duct stones.

The over-all mortality, for the ducts explored, was seven deaths of 132 patients for a mortality rate of 5.3 per cent. The highest rate was 13.6 per cent in the patients with acute cholecystitis, and the lowest 2.38 per cent was in those with chronic cholecystitis. This would indicate rather clearly, that in the patients acutely ill with acute cholecystitis in the absence of deep jaundice, one should be hesitant to perform choledochostomy at the time of cholecystectomy or cholecystostomy.

DEATHS

There were a total of ten deaths in the group of 556 patients, for a mortality rate of 1.79 per cent. It is of interest to study the deaths. (Table VI.) The youngest patient to die was sixty-five years of age and the oldest eighty. The average age of those who died was 72.1 years. Four of the patients were described by the historian as obese. It is evident to surgeons that obese people, particularly elderly obese people, do not stand major operative procedures as well as slender elderly people and certainly it is less difficult to operate on the latter.

Six of the ten patients had acute cholecystitis and one had a ruptured common duct with bile peritonitis from a common duct stone. Six patients had arteriosclerotic heart disease with or without hypertension. Three were considered critical at the time of operation. One of these was seventy-seven years old and had bile peritonitis. Ravdin says the mortality rate in this group is 25 per cent. Fortunately

only about 2 to 3 per cent of any large group will have a free perforation.

Four deaths could be attributed to complications. Two patients had wound eviscerations, one followed a subcostal incision and one a right rectus incision. In one of these patients thrombophlebitis developed and in the other a pulmonary embolus. One died of peritonitis following a second choledochostomy for an overlooked stone thirteen days after the first choledochostomy. This patient probably should not have been explored at this time. In one patient liver abscesses and mucormycosis of the brain developed.

One patient died as she was being transferred from the operating table to the stretcher. She was obese, sixty-eight years old, and had been sick only forty-eight hours. She was admitted to the hospital and operated on the same day, after what was probably an inadequate study. She had cholecystectomy and choledochostomy. No stone was found in the common duct. She probably should not have been operated on so early. Postmortem study showed massive atelectasis of the lungs with severe emphysema and generalized arteriosclerosis.

Another patient aspirated vomitus on the table, a wound dehiscence developed on the thirteen postoperative day and then phlebitis; the patient died ten days after re-suture of the wound. This points up the fact that patients with acute cholecystitis should have nasogastric suction prior to operation.

COMPLICATIONS

The usual complications were encountered in this group of patients. All will not be commented upon. However, it is of interest that there were two subphrenic and one subhepatic abscess. These were drained and all patients recovered. There were two patients with wound eviscerations and both of these died. Of much interest was one patient who had cholecystectomy and a few days later became jaundiced. An exploratory was performed and he was found to have an ascaris, which was blocking his common duct. Removal of the worm produced a cure.

In one patient multiple liver abscesses developed and he died. Postmortem study revealed also that there was mucormycosis of the meninges.

SUMMARY

A study has been made of 556 patients operated upon for inflammation or stones in the extrahepatic biliary system. The mortality rate for cholecystectomy alone was .51 per cent. For cholecystectomy plus choledochostomy, it was 3.57 per cent. The mortality rate in acute cholecystitis was 4.51 per cent; in those having only cholecystectomy, 2.3 per cent; and only cholecystostomy, 3.8 per cent; and in those having cholecystectomy plus choledochostomy, it was 13.6 per cent. This would indicate that in the presence of an acute condition of the gallbladder in an elderly patient, the indications for exploration of the common duct should be clear and in the absence of jaundice, one should seriously consider postponing this procedure until a later date.

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A Five-year Survey of Acute Appendicitis

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A TOTAL of 173 cases, seen between January 1, 1950 through January 1, 1955, was reviewed at Maumee Valley Hospital, Toledo, Ohio. This included perusal of histories; physical examinations; operative procedures; laboratory examination, when performed; and clinical course, if at all significant. Histological examinations of tissues removed were carefully reported using three cross sections of the appendix in each case: the base, mid-portion and the distal end. Cases include patients who came in with a diagnosis of acute appendicitis and who presented sufficient signs and symptoms to warrant operation.

There were 104 males and 69 females, giving a ratio of 1.5:1, males predominating. One hundred seventeen patients were Caucasian (68 per cent) and the rest were Negro (32 per cent). The ages ranged from four weeks to eighty-six years, with an over-all average age of 37.7 years. There were sixteen patients over sixty and twenty-six patients under twelve. It is worthy to note the very low incidence in female Negroes, a mere .08 per cent of the total cases.

OBSERVATIONS

Symptomatology. The average duration of onset of symptoms to hospital admission was 2.6 days and an average of 16.03 hours' stay in the hospital before surgery was performed. Tables I, II and III list the presenting symptoms, which I have tabulated in order of their frequency and their percentage of occurrence in this series.

Temperature. The temperature ranged from 98 to 104°F., with an average of approximately 100°F. Usually a temperature above 101°F. in this series was related to some form of complicated appendicitis. There was only one instance in which a patient with a temperature of 103°F. did have an uncomplicated acute appendicitis. It is not uncommon to find a low grade fever or even a subnormal temperature associated with a complicated case. In our cases there were about fifteen patients with such a temperature.

Physical Findings. In all these cases slight to severe tenderness in the right lower quadrant of the abdomen was invariably present. Approximately eighty patients had rigidity varying from slight muscle guarding to definite rigidity. Those patients with generalized abdominal pain either as onset or radiation pain almost always had accompanying generalized tenderness and less commonly rigidity and

TABLE I
ONSET OF ABDOMINAL PAIN

Site	No. of Cases	Per cent
Right lower quadrant of abdomen	65	37
Periumbilicus	40	23
Epigastrium	26	15
Generalized	25	14
Right upper quadrant of abdomen	6	3
Left flank	6	3
Left upper quadrant of abdomen	3	1.7
No pain, but nausea and vomiting	..	1

TABLE II
RADIATION OF PAIN

Site	No. of Cases	Per cent
Right lower quadrant of abdomen	87	50
No radiation	65	37
Generalized	6	3
Mid-abdomen	6	3
Left flank	5	2
Epigastrium	3	1.7
Right upper quadrant of abdomen	1	0.5

rebound tenderness. Bowel sounds were not evaluated because of inadequate records.

Laboratory Data. There were twenty-one cases with positive urinalysis, an occurrence of 12 per cent in this series. A white blood cell count of more than 5 per high power field with positive albumin was taken as the criteria for a positive urinary finding.

TABLE III
OTHER SYMPTOMS

Symptoms	No. of Cases	Per cent
Nausea and/or vomiting	111	64
Anorexia	16	9.2
Diarrhea	14	8.3
Constipation	11	6.4
Urinary symptoms (urinary frequency, burning, dysuria, etc.)	8	4

Table IV shows the frequency of leukocytosis in these patients.

TABLE IV

White Blood Cell Count	No. of Cases	Per cent
Below 10,000	44	26
Between 10,000 and 15,000	59	35
Between 15,000 and 20,000	43	25
Above 20,000	21	16

The differential count revealed a shift to the left in about 80 per cent of the cases. The rest of the patients, not represented in the figures in Table IV, either did not have white blood cell counts taken before surgery or records have been lost.

Diagnosis. One hundred sixteen patients of the total number of cases presented herein were histologically proved to have acute appendicitis. The rest were diagnosed clinically as such both preoperatively and postoperatively, but with a negative microscopic examination. This gave a 67 per cent correct diagnosis. In the 377 cases reviewed by Dr. F. A. Vicari [1] of Chicago in three hospitals, he noted a correct preoperative diagnosis in 71 per cent. As has been noted by several authors, the history and physical examination still hold as the best criteria for the diagnosis of acute appendicitis. The typical history of generalized abdominal pain followed or accompanied by nausea and vomiting, with radiation or shift to the right lower quadrant plus a moderate rise in temperature and leukocytosis has long been taught in medical schools. However, this should serve only as a guide, not as a yardstick.

McLaughlin [4] lists the differential diagnoses with which acute appendicitis may be confused, according to ages:

THE COMMON CAUSES OF ABDOMINAL PAIN SIMULATING ACUTE APPENDICITIS:

A. Children:
   - Mesenteric adenitis
   - Gastroenteritis
   - Meckel's diverticulitis
   - Pyelitis
   - Ovarian cyst
   - Torsion of ovary
   - Intussusception, volvulus and primary peritonitis

B. Youth and middle age (both sexes):
   - Perforated viscus or ulcer
   - Acute gallbladder
   - Mesenteric adenitis
   - Pancreatitis
   - Diverticulitis
   - Renal colic
   - Pyelitis

C. Common only in female:
   - Bleeding ovary
   - Ovarian cyst
   - Acute salpingitis
   - Ectopic pregnancy
   - Retrograde menstrual bleeding
   - Torsion of uterine fibroids

Mortality and Morbidity. The average stay of patients in the hospital after surgery was 8.17 days. The range of stay was from two to forty days. There were forty-four cases (24 per cent of the total) with complications. Table v illustrates the yearly frequency of complications in this series, consisting of a five-year period ending in 1955.

There were three deaths in this five-year survey, giving a mortality of 1.7 per cent. Two deaths resulted from cardiac arrest and one from fulminating peritonitis secondary to perforated appendicitis.

The mortality rate of appendicitis before 1895 was 72.2 per cent [2]. Of course it might have been higher since this rate was based on

cases which were centered almost exclusively around foreign bodies in the appendix, mainly pins.

Uncomplicated acute appendicitis has had a low mortality rate for many years; at present it is at insignificant levels. In our series, as shown, there were only three deaths in five years, giving a 1.7 per cent mortality. Two of these deaths were due to cardiac arrest which was not directly related to this condition. One case directly related to this pathologic process occurred in an elderly man whose condition was diagnosed as intestinal obstruction. At operation a perforated appendix with fulminating peritonitis was revealed. This gives us an actual 0.5 per cent mortality.

TABLE V
COMPLICATIONS*

Year	Gangrene	Perforation	Abscess	Incarcerated Inguinal Hernia	Peritonitis
1950.....	6	2	.....	.....	.....
1951.....	3	5	1	.....	.....
1952.....	8	6	1	.....	1
1953.....	4	2	.....	.....	.....
1954.....	2	2	.....	1	.....
Total.....	23 (13%)	17 (10%)	2 (1.7%)	1 (0.5%)	1 (0.5%)

* Over-all percentage of complications was 25.7.

Mortality most commonly occurs in cases complicated by gangrene, perforations, peritonitis and abscess. The present day, semi-perfected management with good preoperative and postoperative care and good anesthesia has brought down mortality to the desired low levels. Age is another important factor in the occurrence of complications and the rise in mortality. The age distribution in our forty-three cases of complicated appendicitis is shown in Table VI. Approximately 48 per cent of the complications occurred in patients over forty, and 18.6 per cent occurred in patients under the age of twelve. These figures represent an approximate 66 per cent occurrence of complications exclusive of older age groups and children.

Boyce [3] summarizes as follows in a review of 7,613 surgical cases at the Charity Hospital of Louisiana at New Orleans for a twenty-year period: (1) Age group over thirty-nine years has accounted for the smallest proportion of cases and the largest proportion of deaths. (2) Patients in older age groups have made up an increasingly larger percentage of the total number of cases: 1933, 8 per cent; three-year period ending in 1952, 19.5 per cent. Review of our present series corroborates these findings.

Cantrell and Stafford [5] state that "the residual mortality from appendicitis is determined by the incidence of perforation, since death rarely occurs with unperforated appendicitis. Reduction of mortality depends primarily on prevention of perforation. This in turn depends on educating laymen to seek early treatment and physicians to operate early if appendicitis is suspected."

TABLE VI

Complication	Above 40 Years	Below 12 Years	12–40 Years
Perforations (17).....	12	2	3
Gangrene (22).....	7	3	12
Abscess (2).....	1	1	..
Peritonitis (1).....	1	..	..
Incarcerated hernia (1)..	..	1	..

Management. All these patients were treated by appendectomy with an average of 16.03 hours' stay in the hospital from the time of admission to the time of surgery, as stated previously. The shortest stay was one hour and the longest eight days. Drains were used in twenty-two cases. Antibiotics were given in 120 cases, consisting mainly of penicillin and streptomycin; in occasional cases terramycin,® aureomycin,® gantrisin® and chloromycetin® were administered.

SUMMARY

One hundred seventy-three cases of acute appendicitis seen from January 1, 1950 to January 1, 1955, at Maumee Valley Hospital are reviewed. The ratio of occurrence was 1.5 male to 1 female, and the average age was 37.7 years. The average duration of symptoms before admission was 2.6 days, and prior to surgery 16.03 hours. There were forty-four cases of complications consisting of gangrene, perforation, peritonitis, abscess and incarceration in inguinal hernia. There were three deaths, two from cardiac arrest and one from fulminating peritonitis. The complication and mortality rates presented are 25.7 per cent and 1.7 per cent, respectively.

Records have shown that morbidity and mortality rises with older age groups and children, paralleling the rise of complications in this age group. The over-all morbidity and mortality rates have decreased because of advances in present day management.

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Metal-Tipped Plastic Intravenous Needle

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THE need for a flexible needle for intravenous therapy has prompted the search for a simple unit that is easily inserted and withdrawn. In addition, the needle should be inexpensive enough to be a throwaway, especially when it has been used for transfusions. It must lend itself to easy sterilization either by autoclaving, boiling or immersion in the usual antiseptic solutions. It should be flexible enough to permit the elimination of the arm board, to permit free motion of the arm, forearm or elbow without restricting the free flow of the intravenous solutions or blood.

The needle to be described meets the foregoing criteria. It is made of a strip of teflon tubing, about gauge No. 18 or other sizes if desired. One end is tipped with metal for easy insertion through the skin and into the vein. The teflon is so crimped between two ferrules that it cannot be pulled apart. It is absolutely safe. The other end is firmly attached to a Luer hub for connection to the adapter of the intravenous solutions.

Because of the smoothness of the teflon and its non-irritating qualities, this needle may be left in the vein for days.

Figure 1 shows the needle at the right and the stylet at the left.

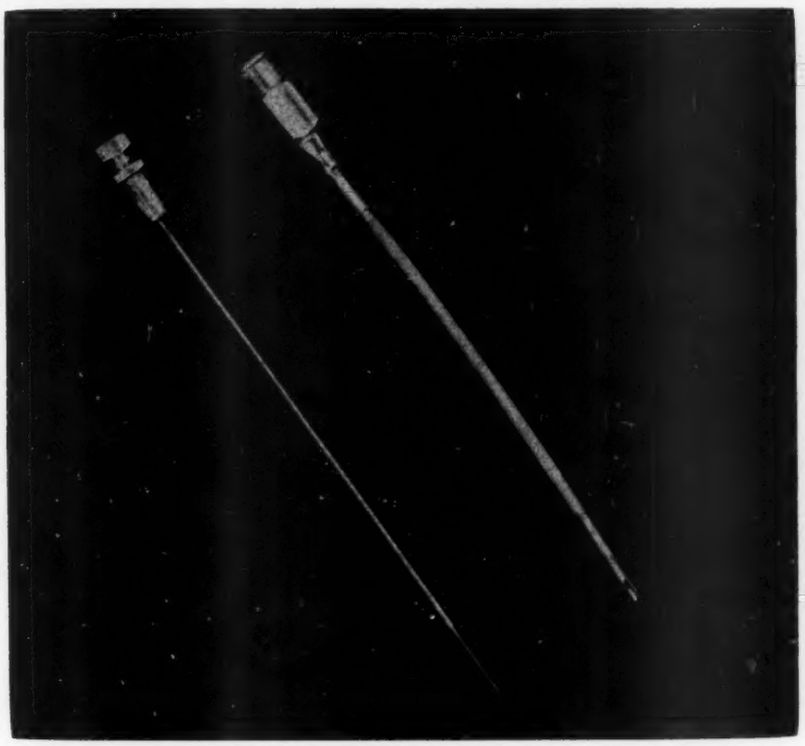

FIG. 1.

Cassette Holder for Use during Reductions of Fractured Bones

JOHN T. BATE, M.D., *Louisville, Kentucky*

THE device to be described is a Universal mechanical clamp designed to hold the cassette in a desired position without slippage. The clamp consists of aluminum jaws adjustable from 8 to 11½ inches. One jaw of the clamp is fixed; the other jaw is moved laterally by turning a hand knob which actuates a bronze T-nut, to which the jaw is attached. The body of the clamp is aluminum and measures 5 inches long, 3 inches wide and 1¼ inches thick. It has a ½ inch diameter threaded hole in the bottom center for use in locking the clamp body to an extension arm. The extension arm is made of aluminum 3/16ths inch thick, 3 inches wide and 18 inches long, with two aluminum stiffening bars attached to the underneath side for structural stability. This piece contains a machined slot ¼ inch wide and 6 inches long

1

2

FIG. 1. Cassette holder and Universal arm attached to "Tilt-All" tripod. By sliding the clamp in the machined slot, an excursion from right to left of 6 inches can be obtained and the clamp rotated through a complete circle. A sandbag, wrapped in a white cloth for contrast, has been placed on the counterbalance. This is really not necessary until the cassette holder is at the end of the Universal arm.

FIG. 2. Clamp attached to the end of the Universal arm.

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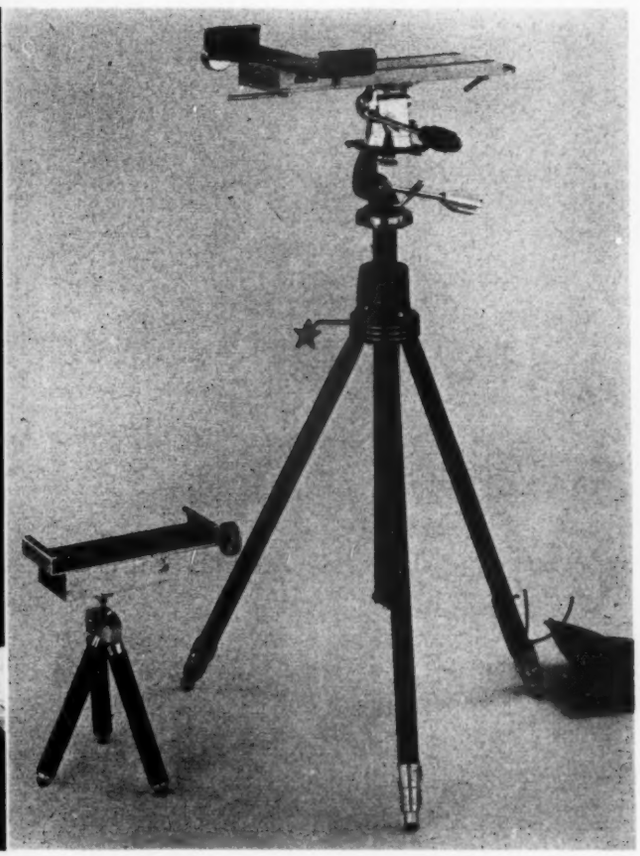

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FIG. 3. Showing additional flexibility of position and extension of the tripod.

FIG. 4. The "Star-D" photographic tripod has the first model cassette-holding clamp and Universal arm attached. A second "Panhead" has been added. The cassette can be placed in any position with this instrument. The small Rowi tripod has a holding clamp attached. It can be extended to any desired height, and used for anterior-posterior and lateral positions.

which provides the means for locking the clamp to the arm with 6 inch adjustment in this plane. (Figs. 1 and 2.)

The extension arm is attached by means of a stainless steel plate and key arrangement to a "Tilt-All" photographic tripod 4602. The extension arm is easily removed by operation of a knurled thumb screw.

Adaptation of the mechanical clamp to the features which are standard to the tripod results in a mechanism which is easily and quickly adjusted to hold the cassette in any desired position in any plane. An adjustable flip-down stabilizer has been added to one leg of the tripod to act as a counterbalance. A sandbag such as is usually found in any operating or x-ray room can be placed upon this to give greater stability. (Fig. 3.)

An earlier model was fashioned to fit on a "Star-D" photographic tripod. This tripod had the advantage of moving up and down by means of a small hand crank. After the second model was made to fit the "Tilt-All" tripod, it was found that by adding a second "Panhead" to the "Star-D" tripod even a greater variety of positions could be obtained with the first model than with the second. (Fig. 4.)

A mechanical clamp can also be attached to a simple Rowi type photographic tripod and used for anterior-posterior and lateral films in many positions. The 6 inch legs on this tripod can be readily extended to any desired length.

Acknowledgment: I am indebted to Mr. R. J. Hancock, Mechanical Engineer associated with the W. R. Martin Company, Louisville, Kentucky, for assistance in design and machine work.

Congenital Unilateral Cystic Kidney

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From the Department of Urology, St. Francis Hospital, Evanston, Illinois.

CONGENITAL unilateral cystic kidneys occur infrequently. Excluding the typical polycystic disease, there have been less than twenty reported cases that seem to fit into such a category. Since there is some variation in the classification of unilateral cystic kidney, each case reported should help materially in arriving at a more universally accepted classification.

Congenital unilateral cystic kidney differs from polycystic and multilocular cystic kidney. Polycystic kidney disease is generally considered as a bilateral involvement. Unilateral polycystic disease is rare and its existence is doubted by many. Bell [*1*], grouping his own cases with others reported in the literature, found that in thirty-one of 395 cases of polycystic kidney unilateral involvement was demonstrated.

The classical infantile polycystic kidney is a bilateral disease. The kidneys are riddled with innumerable small cysts of fairly uniform size, giving it the characteristic "honeycombed" appearance. Interspersed between the cysts are compressed wisps of normal renal parenchyma. The ureter, pelvis and calyces are normally developed as a rule, and the vascular elements show quite normal structure and arrangement. The polycystic kidney retains a semblance of gross renal configuration. Multilocular cystic kidney involves a portion of the kidney.

Nineteen cases almost identical to the present report were found in the literature. Of these nineteen patients, seventeen were treated surgically, and in two polycystic kidney was discovered at autopsy. The ages ranged from newborn to seventy-four years of age, with all but three patients under two years of age.

The predominant sign was an abdominal mass which, in some instances, felt lobular and cystic. In only two cases were other congenital anomalies reported. Three cases were described as multilocular. In nine cases an abnormal or aberrant blood supply was mentioned. Cartilage was seen histologically in two patients. Perhaps the most interesting and significant pathological finding in these kidneys was maldevelopment of the ureter, which was either absent, atretic, narrowed or otherwise impervious.

Several theories have been advanced as to the pathogenesis of this condition, by Ravich and Sanford [*2*], Bunge and Harness [*3*], Hepler [*4*], Howze and Hill [*5*] and Spence [*6a, b*]. Briefly, the condition seems to be a non-hereditary congenital defect of fetal maldevelopment.

The two cases presented herein may be classified as unilateral cystic kidney, according to the classifications of Schwartz [*7*] and Spence [*6a*].

CASE REPORTS

CASE 1. This interesting type of unilateral cystic kidney in a newborn infant was removed surgically at St. Francis Hospital, Evanston, Illinois, on December 6, 1954.

An infant boy of Mexican parentage (I. L. P., hospital file No. 94366) was delivered at St. Francis Hospital on November 21, 1954, following a full-term pregnancy. His weight at birth was 8 pounds,

FIG. 1. CASE 1. Photograph of infant showing congenital anomalies.

8 ounces. The family history was non-contributory. Physical examination revealed multiple congenital anomalies, including an absence of the right nipple, a brachydactylia of the right hand, and a uniform mass in the left abdomen. (Fig. 1.) The heart and lungs were normal on examination and the right kidney was palpable. The abdominal mass was oval in shape and firmly resilient in consistency. It

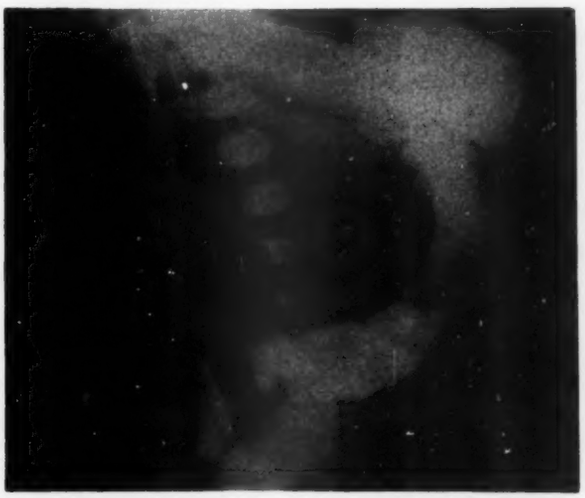

FIG. 2. CASE 1. Barium enema revealed descending colon displaced to left and anterior by large, smooth, homogenous mass.

FIG. 3. CASE 1. Intact surgical specimen viewed from medial aspect. Original magnification, × 2.

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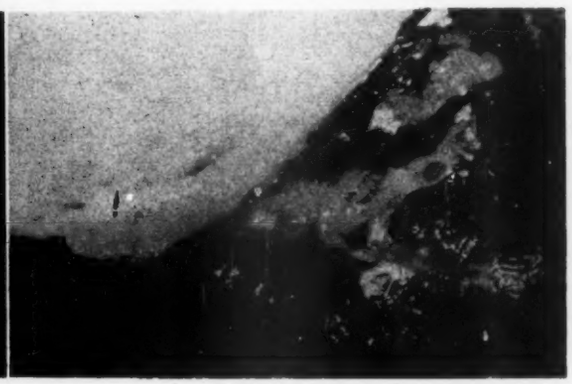

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FIG. 4. CASE 1. Transected surgical specimen revealing interior of larger cyst and at either upper aspect sectioned surface of multicystic renal remnant. Original magnification, × 2.

FIG. 5. CASE 1. Detailed view of multicystic renal remnant revealing smaller cysts in parenchymal mass; central stellate area of fibrous tissue and contiguous wall of larger cyst. Original magnification, × 5.

FIG. 6. CASE 1. Low power view of wall of larger cyst. Note dense vascularized fibrous wall relatively devoid of renal elements, and inner lining of flattened cuboidal epithelium. Original magnification, × 20.

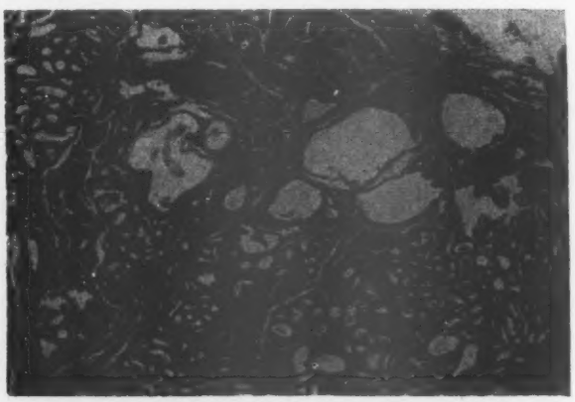

FIG. 7. CASE 1. Peripheral renal remnant incorporates numerous microcysts with cuboidal epithelial lining and amorphous content. Tubular and glomerular (fetal type) elements appear well formed in area, although glomeruli tend to occur in close aggregates. Original magnification, × 67.

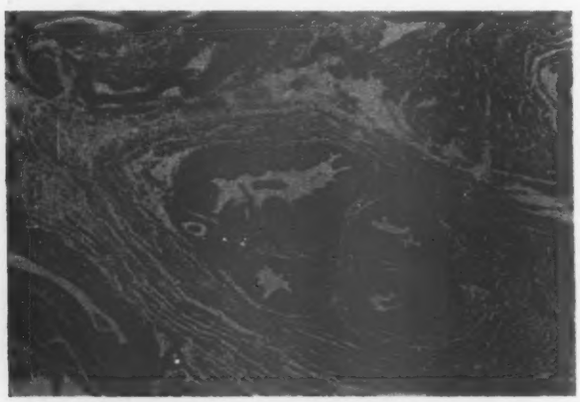

FIG. 8. CASE 1. Ureteric bud structures visualized in denser fibrous tissue areas centralward from parenchymal mass and close to wall of larger cyst. Original magnification, × 40.

was approximately 6 cm. in diameter, with its lower pole directed medially to the right and extending to the midline.

Repeated blood counts and urinalyses were normal. The blood urea nitrogen ranged as high as 34 mg. per cent and the creatinine 2.5 mg. per cent during a brief episode of diarrhea, but fell to normal values after this condition subsided.

X-ray examination of the chest was negative. Flat plate of the kidney, ureter and bladder showed a mass in the left mid-abdomen. Excretory urography revealed an excellent cystogram with only a suggestion of dye in the right renal pelvis, but none on the left. On a barium enema study the descending colon was found to be markedly displaced to the left by the mass. (Fig. 2.) The excretion of indigo carmine dye from the right ureteral orifice was observed cystoscopically. The left orifice was not visualized.

Consultations by the Departments of Pediatrics, Urology, Orthopedics and Surgery resulted in a tentative diagnosis of an abdominal mass associated with the left kidney. The impressions favored Wilms's tumor or a neuroblastoma, while renal cystic disease was considered a possibility. Surgery was advised as soon as expedient.

At the age of fifteen days, the infant was in condition for surgery. The mass was approached retroperitoneally through a transverse left upper quadrant incision extending into the left flank. When Gerota's fascia was entered, a large freely movable cystic mass was encountered and delivered by blunt finger dissection. One small vessel was seen to enter the superior pole of the mass. No ureter, pelvis or normal pedicle were noted. The peritoneum was opened and the right kidney was normal to palpation. Left nephrectomy was performed. Pathologic study by Dr. James W. Henry showed the following: The specimen consisted of an ovoid cystic mass of tissue which measured 6.8 by 3.5 by 2.4 cm. The external surface was taut, glistening and reddish tan in color. Coursing over the surface was a network of small blood vessels. (Fig. 3.) Sectioning revealed one large oval cyst of the dimensions just mentioned and numerous tiny cysts incorporated in a nodule of solid tissue situated at one pole and measuring 1.8 by 1.2 by 1.4 cm. (Figs. 4 and 5.) The cysts contained a clear serous fluid and the inner linings were glistening and grey-white in color.

Microscopic diagnosis revealed a congenital polycystic kidney (apparently unilateral). The cystic kidney revealed one large cyst and a collection of smaller sized cysts with intervening areas of kidney parenchyma. In these areas the glomeruli were developed and there were tubular structures suggestive of nephrogenic ureteral buds. There was one small focus of cartilage-like material adjacent to several glomeruli. (Figs. 6, 7 and 8.)

FIG. 9. CASE I. Right retrograde urogram taken four months postoperatively.

The postoperative course was uneventful and the infant was discharged twenty-one days after surgery.

The baby was readmitted to the hospital on March 14, 1955, at four months of age, for follow-up studies. He showed normal weight gain and development. The blood count and urinalyses were normal, the blood urea nitrogen was 17 mg. per cent and the creatinine was 1.05 mg. per cent. Cystoscopy was done again and a normal bladder with normal ureteral orifices was visualized. Retrograde urography demonstrated a normal collecting system on the right side. (Fig. 9.)

CASE II. L. O., a white woman, fifty-three years of age (file No. 22978), was surveyed urologically at St. Francis Hospital on April 10, 1951, because of subacute intermittent epigastric distress and a history of left renal cysts.

Physical examination and routine laboratory findings were normal. At cystoscopy the bladder and right renoureteral tract were found to be normal in function. The left ureter was occluded 17 cm. above the ureteral orifice. The urogram revealed a normal upper right urinary tract. There

FIG. 10. CASE II. Retrograde urogram revealing normal right pyelogram, calcific ring shadow left renal area, with arrested ureteral catheter.

FIG. 11. CASE II. Lateral view flat film showing calcified cysts.

12A 12B

FIG. 12. CASE II. Comparison of calcific shadow in our Case II (A) with similar case of Harry M. Spence (B).

were multiple spherical shadows, rim-like in character, occupying the left renal region and similar to but differing from calcified hydatid cysts of the kidney. (Figs. 10 and 11.)

The patient's symptoms and findings have not warranted surgery.

An opinion, by mail, from Mr. G. L. Rolleston [9], Christchurch Hospital, Christchurch, New Zealand, carefully differentiated the urogram from that of hydatid disease.

The pathogenesis in this case was suggested by a urogram published by Harry M. Spence [6a] in his article, "Congenital Unilateral Multicystic Kidney," in December, 1955. His case (No. IV), through the courtesy of Dr. Jon R. Werner, was that of a woman, seventy years of age, in whom the urogram was identical except transposed. Surgery was necessary in his case, and the cysts were removed from the perirenal fat. No kidney was demonstrable. The pathologic diagnosis was "embryonic mesonephric renal tissue with fibrocalcific nodules." (Fig. 12.)

In a personal communication, after viewing the urogram of this case, Dr. Spence aptly stated it to be "practically a mirror image" of the one he published.* It is probable that the pathology in this case is similar and that a diagnosis of multicystic kidney in an adult is justified.

SUMMARY

Two unusual types of multicystic kidney disease are presented, one in an infant similar to eighteen previously reported cases, and one in an adult, the replica of one previously reported case. The condition is believed to be congenital, unilateral, and unlike polycystic kidney.

Acknowledgments: We wish to thank Dr. James W. Henry, pathologist, and Paul Jorgensen, photographer, for their interest and assistance in preparing this paper. Also, our appreciation of the helpful and detailed opinions so graciously communicated by Mr. G. L. Rolleston and Dr. Harry M. Spence.

* To be available at a later date.

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Renal Adenoma

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From the Urological Service of the Beth Israel Hospital, Boston, Massachusetts. Read at the meeting of the New England Section of the American Urological Association, Boston, Massachusetts, November 7, 1956.

Despite the appellation of benign renal adenoma, this entity has been handled, on most occasions, as if it were a malignant lesion. Usually it causes no symptoms, and is a coincidental finding. Symptomatology is usually produced by coexisting pathology, as, for example, ureteral or renal calculus.

Cases of renal adenoma have been described often in the literature since the first report of Sturm [*1*] in 1875. Some of these were diagnosed clinically in patients who were seen because of urinary tract symptoms, or because of the presence of an abdominal mass. Most were treated by nephrectomy. Many more instances have been reported of "non-clinical" adenoma, found at autopsy, or incidentally during the course of renal surgery.

The small, usually non-clinical, adenomas are seen most often in kidneys which have been previously scarred by localized vascular occlusion, or an arteriosclerotic basis [*2–4*]. It has been postulated by Sturm [*1*], Ewing [*2*], and other more recent writers [*3,4*], that tubular necrosis follows the vascular occlusion, and that the tubule then becomes fragmented into segments. The ends of the segments then become sealed, forming small cysts, within which the tubular cells proliferate forming an adenomatous nodule. This type is seen usually in patients in the fifth decade and later, the incidence increasing with each subsequent decade. These adenomas are usually found in the subcapsular area in which terminal vessels are most evident. They are seen in association with microscopic cysts, presumably caused also by tubular necrosis or tubular obstruction. In a series of cases reported by Nuernberg [*5*], gross or microscopic cysts were found in all but two of sixty-six cases of adenoma.

It has been shown that vascular occlusion (i.e., of a glomerulus) does not necessarily lead to necrosis of tubules. Oliver and Lund [*6*], and Oliver and Luey [*7*] in studies of the kidney of chronic glomerulonephritis, demonstrated Ludwig's vessel in instances dilated to a caliber equal to that of the parent arteriole, and believed that this offered an alternate blood supply. Oliver and Luey also showed that the tubules of occluded glomeruli could even undergo hypertrophy, dilatation and hyperplasia. Trinkle [*8*] also stated that tubules of an obstructed glomerulus may get a new blood supply from adjacent tissue, or from the renal capsule.

Albarran [*9*] believed that the precursors of adenomas were islands of imperfectly developed or displaced tubules, due to abnormality of fusion of nephrogenic and wolffian elements. This may be offered by way of explanation of adenomas seen in younger people, with no evidence of vascular occlusion. To further fortify this concept of displacement of tubules, Ewing writes of the development of adenoma and adenocarcinoma in pararenal rests. He also mentions a case of Antona, in which a renal type tumor was found outside the kidney.

Adenomas of the kidney usually are about pea-size and no larger than walnut-size. Most commonly they are single, but they may be multiple and occasionally bilateral. Usually they are seen in the cortical or capsular area, but they may be seen in the medullary region and have been reported to project into the calyces [*10*]. They are described as being papillary, tubular, or alveolar in type, depending on their microscopic appearance [*2*]. The papillary type is most common and shows outgrowths arising from the cyst wall. The lining cells may be granular or opaque; in very early papillary tumors, there may be large clear cells with fat and doubly refractile lipoid material. The tubular type shows long and irregular

branching channels lined by small cells free of fat and consisting chiefly of nuclei. The stroma is abundant and vascular. The alveolar type shows cells of cubical or cylindrical structure of large size. They are often fatty, but in some, the cells are granular and free of fat. In one case of polyadenomatous kidney all three types were seen.

There are several secondary changes which have been seen in adenomas [2]. They are fatty degeneration, fibroid and sarcomatoid changes, cavernous blood vessels, pigmentation, and even complete replacement with fat tissue.

Many authors have upheld that all adenomas begin with cyst formation which follows the tubular necrosis within the cyst. Trinkle [8] says papillary proliferation can begin locally or generally. This forms a papillary cyst. Then papillary cystadenomas develop and can further proliferate to form solid papillary adenomas. Then, the proliferating epithelium may bud off from the main mass and form small masses of epithelium free from connective tissue. These buds may differentiate into tubules. Trinkle points out that the larger adenomas, described as being of the tubular type, often show areas of papillary structure suggesting that this theory of their origin may be correct. As the tumor grows it compresses adjacent renal tissue and a fibrous capsule develops.

The question of greatest importance is the relationship of the "benign" adenoma to renal carcinoma. Often there is difficulty in differentiating adenoma from carcinoma histologically [3]. In some cases reported, there has been invasion of the fibrous capsule by benign adenoma [11]. There have been instances of benign adenoma merging with tumor tissue which microscopically was hypernephroma. In a series of four cases of well encapsulated hypernephroma seen by Trinkle [8], transitional forms of adenoma were seen. Other cases have been reported which give some indication that malignant renal lesions may stem from a preexisting adenoma. Gray [12] described a case of renal tumor found at necropsy in which were found hypernephroma, "papilliferous" cystadenoma and some intermediate types. There were also some areas which were tubular in arrangement. These were seen in a lesion 5.5 cm. by 6.5 cm., which was well encapsulated. Still another case report which may further demonstrate some relationship between the benign adenoma and malignant renal lesion is one by Nicholson [13]. He performed a nephrectomy for hypernephroma in which there was no papillary component present. Six months later an incisional mass was removed from this patient with a microscopic diagnosis of papillary adenoma.

FIG. 1. Intravenous pyelogram made six months prior to operation. The soft tissue mass of the lateral border of the left kidney is well seen. The calculus, at this time, was in the renal pelvis.

The size of the adenoma evidently cannot be an index of benignity or malignancy. Gordon-Taylor [14] reported a "gigantic benign tumor of the kidney" weighing 22 pounds. Nephrectomy was performed and the patient was well eight years later when the case was reported. The mass measured 13 inches by 11 inches by 5 inches. The microscopic diagnosis was adenofibroma, as there was a large amount of fibrous stroma, scattered about in which fairly numerous tubules were present. This lesion, because of its abundant stroma, was somewhat different from the typical adenoma.

The authors here present a case in which a benign renal tumor was encountered as an incidental finding in the presence of renal colic due to a calculus.

CASE REPORT

A thirty-nine year old white man was seen with the complaint of left flank pain and hematuria. There were no other urinary symptoms. On physi-

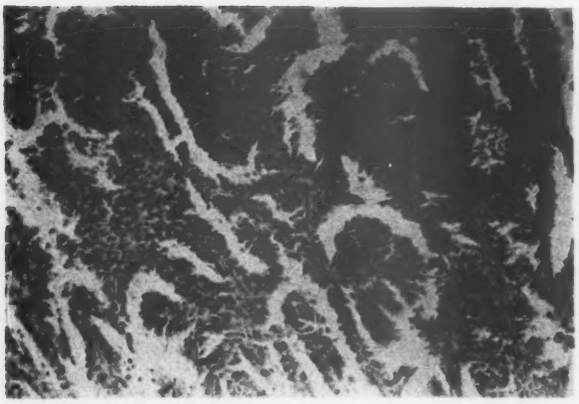

FIG. 2. Microscopic pathology of the papillary adenoma.

cal examination he was found to have slight left costovertebral angle tenderness and tenderness along the course of the left ureter. His urine contained many erythrocytes and occasional leukocytes per high power field. Hemoglobin was 16 gm. per cent; white blood count was 6,000/cu. mm.; fasting blood sugar was 100 mg. per cent; nonprotein nitrogen was 22 mg. per cent; phosphorus was 2.8 mg. per cent. An intravenous pyelogram revealed a calculus 2 mm. by 5 mm. in the left renal pelvis. (Fig. 1.) An additional radiographic finding was a spherical mass 3½ cm. in diameter, on the mid-portion of the lateral surface of the left kidney. There was no distortion of the calyceal system. Cystoscopy and left retrograde pyelography revealed the same findings, but the outline of the mass was not as distinct. Again there was no distortion of the calyceal system. The decision was made to follow-up the patient and repeat the intravenous pyelogram. This was done five months later and the calculus was found to be lying in the upper ureter. A spherical soft tissue mass of the left kidney with a normal calyceal pattern was still reported. Surgery was advised. At operation the calculus was removed from the ureter at the level of the fourth lumbar vertebra. The kidney was then exposed and a solid, smooth, round, whitish tumor was seen. It was about 3 cm. in diameter and was on the lateral surface close to the margin at the mid-half of the kidney. An incision was made into normal renal parenchyma adjacent to it and the mass was then easily enucleated from the parenchyma. There was a good plane of cleavage. Moderate bleeding was controlled by hemostatic sutures and application of gelfoam. Report on the frozen section was renal adenoma. Two empty rubber drains were inserted and the wound was closed in layers. The postoperative course was uneventful except for the passage of bloody urine for the first four days and a mild penicillin reaction. The patient was discharged from the hospital on the eleventh postoperative day. The pathologist's report described the mass as being 4 cm. by 3.5 cm.

FIG. 3. Postoperative film, one year after operation, showing a defect of the outer border of the left kidney, due to operative intervention.

and well encapsulated. The cut surface revealed bright yellow, tan rubbery substance mottled with specks and larger areas of bright yellow. Final microscopic diagnosis was papillary adenoma of the kidney. (Fig. 2.)

The patient did well thereafter, and a follow-up intravenous pyelogram taken one year after operation revealed only a defect of the outer border of the left kidney where the adenoma had been removed. (Fig. 3.)

SUMMARY

In a thirty-nine year old man with symptoms due to a renal calculus, an intravenous urogram revealed a mass on the same kidney. The calculus and mass were removed surgically and an otherwise normal appearing kidney was conserved. On both gross and microscopic examination the mass was diagnosed as a benign adenoma. The patient will be followed up closely with periodic pyelography. We believe that in view of the apparent benignity of this lesion, it was justifiable to attempt to conserve normal renal tissue in this relatively young man.

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Choledochocolic Fistula

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A REVIEW of the literature reveals that a choledochocolic fistula is a very rare phenomenon. The Massachusetts General Hospital reported the only other case which was not diagnosed *in vivo*, but found at autopsy [1]. Because of its rarity the following case is reported in detail.

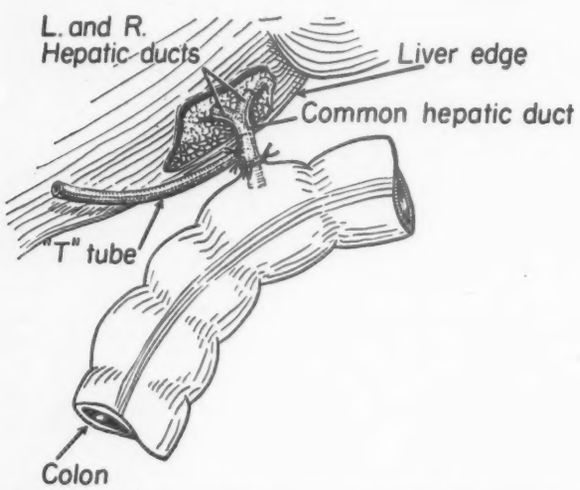

FIG. 1. At the time of the second operation an anastomosis was made inadvertently between the common hepatic duct and the colon instead of with the duodenum.

CASE REPORT

S. R., a fifty-eight year old white man was admitted to the Southampton Hospital with marked jaundice, swelling of both ankles, and cachexia. In a review of his past history it was learned that this patient at the age of thirty-seven had had an attack of colicky pain in the epigastric region which had radiated to the mid-back and had lasted about four hours. He had had a second attack at forty-one years of age which had lasted six hours. Both these attacks had been relieved by the administration of morphine. After that the patient had complained of an intermittent burning sensation in the chest, and nausea following the ingestion of fatty meals. In 1951, at the age of fifty-seven, a cholecystogram had revealed calculi in the gallbladder and in October of that year a cholecystectomy had been performed at another hospital. Following the operation, the patient had become progressively jaundiced. Nevertheless, he had been discharged on his fourteenth postoperative day. Another physician had been consulted, who advised immediate hospitalization in a second hospital. On that admission, his icteric index was 150 and the patient underwent an exploratory laporatomy on November 8, 1951. The following summary of the operative report was: "At operation there were numerous adhesions between the colon, omentum and undersurface of the liver, especially dense in the region of the gallbladder bed. Amidst the adhesions in the area of the foramen of Winslow dissection revealed the presence of a doubly silk tied tubular structure approximately 1.5 cm. from the head of the pancreas. This was interpreted as representing distal completely transected common bile duct. After considerable dissection, another doubly ligated tubular structure in the region of the porta-hepatis, subsequently identified as transected proximal common bile duct was found. The distal portion of the common duct was mobilized after dissection through numerous adhesions. By this manoeuvre, approximately 1 inch of utilizable duct structure was obtained. The proximal common duct stump was mobilized by dividing adhesions and inflammatory tissue at the porta-hepatis. After approximation without tension anastomosis was accomplished using a single row of black silk sutures. A T tube was introduced, one limb of which extended into the hepatic duct and the other limb extended into the remnant of the common bile duct. The duodenum was then attached to the area of the porta-hepatis in an attempt to relieve tension at the suture line." (Apparently due to the dense adhesions the colon was mistaken for duodenum and an anastomosis was actually made between the common hepatic duct and colon.) (Fig. 1.) "A Penrose drain was placed down to the foramen of Winslow after which the wound was closed in layers using continuous catgut for the peritoneum, interrupted wire for the fascia, and interrupted

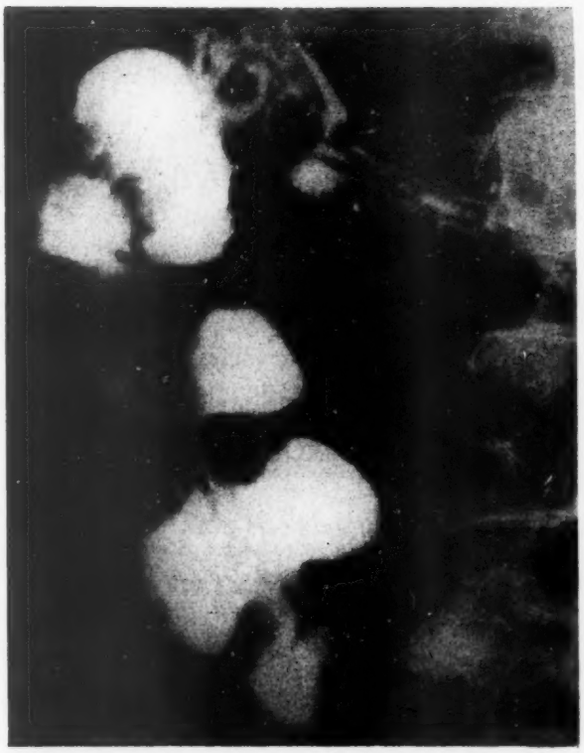

FIG. 2. Cholangiogram. Injection of the T tube outlined the common duct faintly and a few of the biliary radicles. Little of the opaque solution appeared in the common duct. The colon is well outlined by opaque material and none entered the small intestine. This indicated an anastomosis between the common duct and the hepatic flexure.

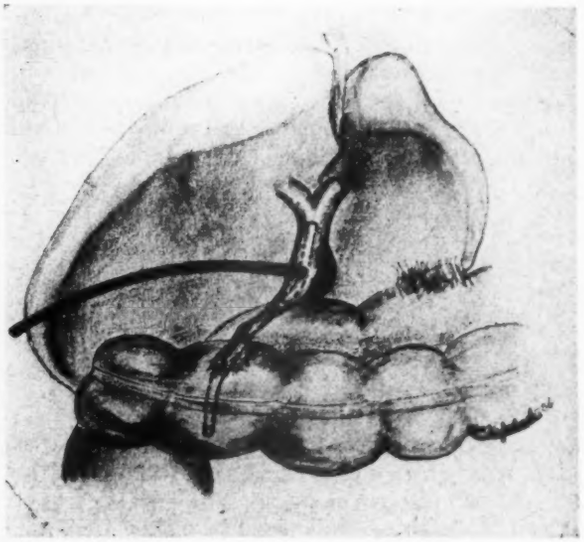

FIG. 3. Drawing showing findings at the time of the third operation when fistulous tract was found between the common hepatic duct and hepatic flexure of the colon. The T tube is still in place. Numerous adhesions which were present are not shown.

silk for the skin. The patient had a stormy convalescence. He ran a prolonged fever with considerable drainage and required numerous transfusions and infusions."

After remaining in the hospital for six weeks the patient was sent to Florida to recuperate. During his stay he lost his appetite, lost weight, had intermittent jaundice, clay colored stools and edema of the ankles developed. He returned to Long Island and was admitted to the Southampton Hospital on March 14, 1952. On admission to the hospital temperature was 99.2°F. He weighed 136 pounds compared to his normal weight of 170 pounds. The skin and sclerae of the eyes were markedly jaundiced. The heart and lungs were normal. There were healed scars of an upper right rectus and a right subcostal incision. There was a T tube in the right upper quadrant which was draining a slight amount of bile. No masses were felt. The spleen was not palpable. The liver was enlarged to about 2 fingerbreadths below the costal margin. It was smooth and tender to touch. There was marked edema of the ankles. Urinalysis revealed a positive reaction for bile. Red blood count was 3.2 million per cu. mm. with hemoglobin of 80 per cent. The white cell count was 6,500 per cu. mm. A cephalin flocculation test was 4 plus. The icteric index was 40. A direct van den Bergh's test was positive. A cholangiogram by injection of dye through the T tube faintly outlined a short common duct and a few biliary radicles. The proximal half of the transverse colon, however, was well outlined by opaque material. None of the opaque solution entered the small intestine and this indicated a fistula between the common duct and the hepatic flexure of the colon. (Fig. 2.)

The patient was given one week of preoperative preparation which included a high carbohydrate low fat diet supplemented with vitamins, saline, amigen,® vitamin K, as well as sulfathaladine administered orally. One pint of whole blood was administered. Operation was performed on March 21, 1952. A small incision was made over the left anterior saphenous vein at the ankle, and a size No. 18 polyethylene tube inserted to provide a suitable channel for the administration of blood and intravenous fluids. There was a dense fistulous tract around the T tube in the right upper portion of the abdomen, just beneath the costal margin. This extended to the hepatic hilum. A transverse incision was made and extended 8 cm. to the left. Fascia and muscle were transected. Peritoneum was opened to the left so that it might be divided at a spot where there had been no adhesions. Dense adhesions were present binding the colon to duodenum, colon to liver, colon to stomach, stomach to liver and omentum to abdominal wall. After all omental adhesions had been divided, the wound was opened for its entire length. Dissection of all

adhesions was then carried out until the hepatic hilum was reached. The choledochocolic fistulous tract was dissected out and cut across, and one limb of T tube was found to extend into the hepatic colon and the other to extend into the proximal remnant of the common hepatic

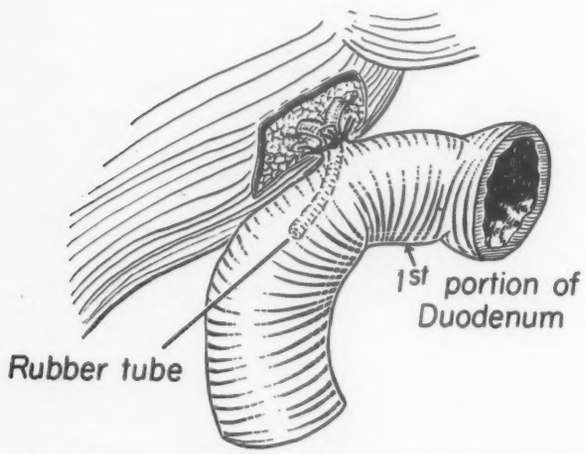

FIG. 4. Diagram showing anastomosis made at the time of the third operation. The common hepatic duct has been joined to the duodenum and a size No. 20 rubber cathether is in place to maintain the anastomosis. This tube was passed rectally thirty-three days postoperatively.

duct. (Fig. 3.) No trace of the original distal portion of the common duct was found. The necrotic fistulous tract into the colon was excised. The colon was closed with a running atraumatic suture in the mucous membrane and interrupted silk sutures in the serosa. A large rubber catheter size No. 20, was then inserted into the common hepatic duct and a small opening made into the duodenum through which the distal end of the tube was extended to approximately 12 cm. Silk sutures were placed to maintain the anastomosis and one silk suture held the catheter in position. The duodenum was then carefully sutured to the liver. The question of attempting to reanastomose the common duct was discussed at operation and discarded since the patient had sloughed his entire distal common duct. A Roux en Y of jejunum was also a possibility, but in view of the degree of infection present and his previous misadventures, the simplest procedure was deemed advisable—that of a direct anastomosis between the duct and the duodenum. (Fig. 4.) The wound was closed after 4 gm. of sulfanilamide were placed in the peritoneal cavity. Closure was with uninterrupted chromic sutures in the peritoneum, muscles, and fascia and interrupted stainless steel braided wire retention sutures. A rubber catheter in a Penrose drain extended down to approximately the old site of Morrison's pouch in the right angle of the wound. Stainless steel wire sutures were used in the skin closure.

Postoperatively, the patient was given daily infusions of glucose in saline, glucose in water, amigen and vitamins. In addition the patient was given 1,000 cc. of whole blood, and 1,000 cc. of plasma postoperatively. He had a rise in temperature to 104°F. on the second postoperative day which gradually returned to normal in four days. A Levin tube with Wangensteen suction was continued for six days. Terramycin® was given intravenously as well as penicillin and streptomycin intramuscularly. The patient was discharged fourteen days postoperatively. There was very slight edema of the ankles. The sclera showed no jaundice and the skin was clear. The patient passed the choledochoduodenal rubber tube rectally thirty-three days postoperatively. Seven months postoperatively, patient showed a gain in weight of 37 pounds. There was no jaundice. The icteric index was 6. No edema of the ankles was seen. The cephalin flocculation test was 2 plus. Twelve months postoperatively, the patient was in excellent health, but eighteen months later, in September 1953, because of recurrent jaundice the patient was admitted to the Lahey Clinic. At operation it was found that the anastomosis which had been made between the common duct and duodenum had practically closed and therefore a hepaticojejunostomy and a side-to-side anastomosis was performed. Since that time the patient has been in good health.

SUMMARY

1. A case of choledochocolic fistula with operative repair is presented.

2. A review of the literature shows this to be the only case in which the patient survived such a fistula.

3. This is an extremely rare condition, and apparently only occurs after biliary surgery. In this patient the common bile duct was completely transected at the time of cholecystectomy. At the second operation an anastomosis was made with the proximal segment of the common bile duct and the colon instead of duodenum.

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Gastric Re-resection

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RE-RESECTION of a gastric remnant, even in what may appear to be a hopeless case, may at times be a rewarding surgical procedure. Many instructive papers on surgical treatment of gastric lesions have been published by clinical and experimental workers who generally agree that there are two fundamental principles necessary for successful gastric resection, namely, adequate resection and an anastomosis so placed that it is quickly bathed in the alkaline pancreatic and biliary secretions. Direct end-to-end gastroduodenostomy following adequate resection fulfills the requirements and obviates most of the problems. Unfortunately this cannot be carried out satisfactorily in many cases, so other procedures must be employed.

When a patient has undergone resection and there is recurrence of disease or the appearance of a postoperative complication necessitating further surgery, the problem is somewhat more complex. Numerous methods have been employed in an attempt to afford these patients satisfactory therapy; still another one is suggested for consideration herein.

In one of the two cases reported in this paper carcinoma recurred in the gastric remnant and at the site of anastomosis, requiring further surgery. In the second case the patient had had gastric resection five months previously for gastric carcinoma. She presented with symptoms which were proved at the second operation to be due to an efferent loop obstruction with afferent loop pooling. Also, a polyp was present at the site of anastomosis which had been believed to be a recurrence of the neoplasm.

CASE REPORTS

CASE I. F. Z., a seventy-two year old white woman, was admitted to Goldwater Memorial Hospital in September, 1955, with the complaints of epigastric pain, loss of weight and inability to retain food.

Past history revealed that the patient had undergone high subtotal gastric resection with retrocolic Polya anastomosis sixteen months previously for adenocarcinoma of the distal end of the stomach.

X-rays on this admission revealed the presence of an obstructive lesion in the region of the gastrojejunostomy. The hemogram was markedly depressed and the patient appeared cachectic and chronically ill.

After adequate preoperative preparation with transfusions and fluid and electrolyte replacement exploration was performed. A large mass was found at the site of the gastrojejunostomy involving transverse colon and spleen.

At operation another higher resection was performed on the gastric remnant taking in the involved jejunum and proceeding very high on the lesser curvature, removing all the nodes present. In addition it was necessary to perform segmental resection of the involved transverse colon and splenectomy. End-to-end anastomosis was performed in the transverse colon, and the continuity of the upper gastrointestinal tract was re-established in a retrocolic position. (Fig. 1.) Postoperative x-rays showed the flow of barium through the gastric remnant and down the jejunal limb. (Fig. 2.)

The patient made an uneventful recovery. She lived for fourteen months after surgery and became an invalid only in the last two months of her life. The first twelve months following operation were quite normal.

CASE II. S. Y., a seventy-four year old white woman, was admitted to the Goldwater Memorial Hospital in January, 1957, with complaints of epigastric pain following intake of food, anorexia and loss of weight.

Past history revealed that the patient had undergone high subtotal gastric resection with antecolic Polya anastomosis five months previously for adenocarcinoma of the distal portion of the stomach.

X-rays on this admission were equivocal. How-

ever, there was a suggestion of possible pooling in the afferent loop and a questionable lesion at the site of anastomosis. The hemogram was depressed and the patient appeared chronically ill.

Because of the persistence of symptoms it was decided to perform exploratory laparotomy (second look) after adequate preparation of the patient with blood and fluids.

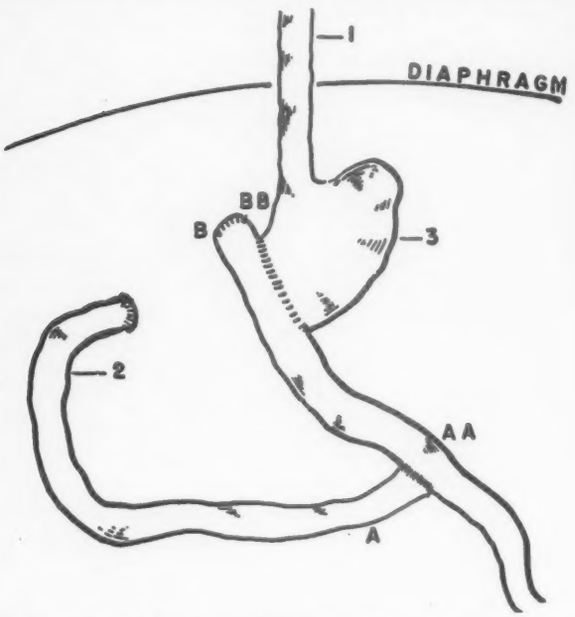

FIG. 1. Drawing of completed procedure. A-AA, jejunojejunostomy. B-BB, gastrojejunostomy with end of jejunum closed. (1), esophagus, (2), duodenum; (3), gastric remnant after re-resection.

At operation a dilated afferent loop was found (obviously the site of pooling) and a peculiar thickening was noted on palpation at the lesser curvature of the anastomosis; this was thought to be a recurrence of disease. The procedure shown in Figures 1 and 3 was performed with the anastomosis done anterior to the transverse colon.

Postoperatively the patient did well as far as the abdomen was concerned. On the seventh day pulmonary emboli developed which were controlled with adequate medication. Later empyema developed on the same side (left) which was treated with repeated aspirations.

The pathological report of the resected specimen in this case did not reveal evidence of recurrent disease. The area at the site of anastomosis that was thought to be carcinoma was a gastric polyp. This procedure was therefore performed for efferent loop obstruction with pooling in the afferent loop and a gastric polyp.

DESCRIPTION OF PROCEDURE

In most secondary operations for gastric carcinoma the outlook is usually most distressing to the operating surgeon. The lesion is usually so far advanced that nothing can be done. However, there are cases in which re-resection may appear to be hopeless and will later prove to be a rewarding surgical procedure. Since resections for carcinoma are usually quite high, the anticipation of further resection of what remains becomes even more challenging. So many of the lesions migrate along the lesser curvature that the removal of almost all of this portion of the stomach becomes mandatory. The re-establishment of continuity then becomes another problem. The angulation of either afferent or efferent limbs becomes a real hazard with the usual gastrojejunostomies and therefore this Roux en Y method is offered for consideration.

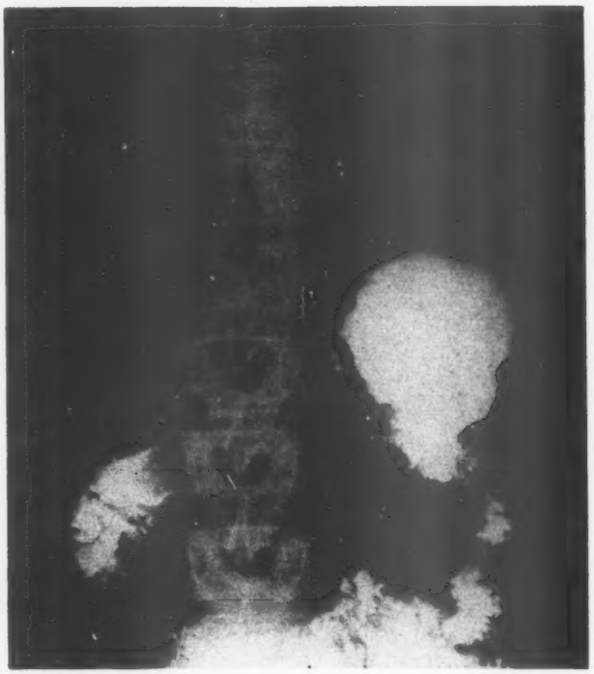

FIG. 2. Case 1. Postoperative x-ray with barium in the gastric remnant and down the jejunal limb.

The resected area is shown in Fig. 3. It involves the greater part of the remaining gastric remnant in cases of carcinoma and includes the entire anatomosis and part of jejunum on either side of the anastomosis. In cases in which there is a dilated short afferent loop secondary to pooling and efferent loop obstruction, this procedure is also of value. It facilitates the reconstruction of the upper gastrointestinal tract with little hazard of post-operative complications. The continuity of the upper gastrointestinal tract is re-established

(Fig. 1) with a Roux en Y procedure closing off the proximal end of the distal jejunal limb and performing end-to-side gastrojejunostomy and then end-to-side jejunojejunostomy below to allow the bile and pancreatic juices to flow

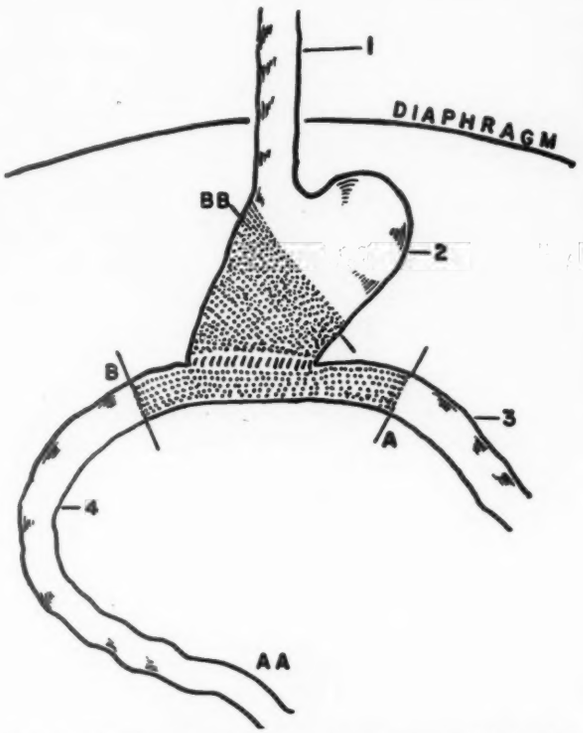

FIG. 3. Diagram demonstrating tissue resected (stippled area). (1), esophagus; (2), gastric remnant; (3), afferent loop; (4), efferent loop. A, area to be anastomosed to AA (jejunojejunostomy). B, area to be anastomosed to BB (gastrojejunostomy).

back into the alimentary canal close to the gastric anastomosis.

The procedure appears to fulfill the requirements previously mentioned, namely, a more adequate resection of the gastric remnant where it may be necessary and the re-establishment of a quasinormal gastrointestinal tract.

COMMENTS

While some clinics advocate complete extirpation of the stomach for malignancy, there are others who disagree with the radicality of the therapy noting in particular that the postoperative morbidity in most cases makes life unbearable. The increasing number of total gastrectomies reported in the literature has been accompanied by a marked reduction in the postoperative mortality rate. However, there has followed a rapidly increasing high

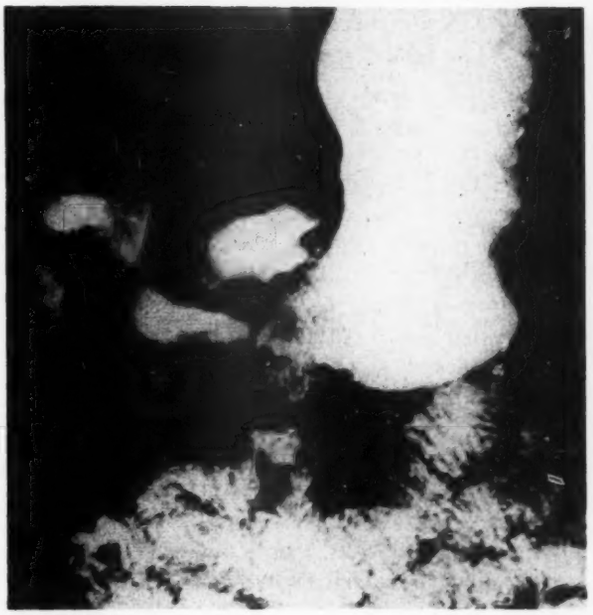

FIG. 4. X-ray film demonstrating a large ulcerating carcinoma of the lesser curvature.

morbidity rate in terms of impairment of digestive function, anemia, malnutrition, stricture at the site of anastomosis, diarrhea and loss of earning power. The vast majority of these survivors become emaciated gastric cripples and they are difficult to manage therapeutically. The general dissatisfaction with the disturbed gastrointestinal physiology is made obvious by the increasing number of publications advocating technical variation of the current methods in use. Repeated attempts and technics for the construction of substitutes for gastric reservoirs by utilizing colon or jejunum reflect the shortcomings of the operation. Of most importance, however, is the fact that no series of total gastrectomies has yet been reported which can equal the survival rates of subtotal resection even though the latter leaves much to be desired. However, one can adopt the philosophy of Wangensteen and take a second look at these cases. If re-resection is feasible, by employing the procedure described herein a portion of the stomach will still be retained.

SUMMARY

1. A procedure employed for re-resection of the gastric remnant is suggested.

2. Two case reports are presented. In one, re-resection was performed for recurrent carcinoma, with a fourteen-month survival. In the second case (short afferent loop pooling) re-

section was also necessary for suspected malignancy. The result was gratifying.

ADDENDUM

Since this paper was submitted for publication a third patient was operated upon at St. Vincent's Hospital in New York City; the surgical procedure described was performed as the primary form of therapy. The patient, a seventy-six year old woman, had had epigastric distress for the past two years. Upon admission she was cachectic and pallid; she had lost 20 pounds in the past six months. Upper gastrointestinal series revealed a very large ulcerating lesion on the lesser curvature. (Fig. 4.) At operation almost the entire lesser curvature was removed up to the esophagogastric junction and the continuity was reestablished as described in Cases I and II. The diagnosis was that of an extensive ulcerating carcinoma of the stomach. Her postoperative course was most benign.

Comment: While total gastrectomy has been suggested for carcinoma of the stomach regardless of the site of the lesion, one has to take into consideration the age of the patient and the probable postoperative complications before subjecting him to such a procedure. With total gastrectomy the esophagogastric sphincter mechanism is destroyed and the difficulties with alkaline esophagitis which is sure to follow are well known. When the lesion is so located that the uppermost segment of stomach and sphincter mechanism can be preserved, it should be considered most seriously. It is doubtful if one can increase the possibility of cure by the excision of the lower end of the esophagus since this would not encompass any additional extragastric dissection of lymph nodes, etc. In summary, in both palliative and curative radical gastrectomies for carcinoma of the stomach in which there is no need to sacrifice the esophagogastric junction, it would appear wise to limit the resection short of the sphincter mechanism and consider the re-establishment of continuity as described previously. The mortality and morbidity would be favorably affected, particularly the morbidity relating to alkaline esophagitis.

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Intestinal Polyposis with Oral Pigmentation

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IN 1949 Jeghers, McKusick and Katz [*18*] first published a comprehensive study of the syndrome of generalized intestinal polyposis, associated with melanin spots of the oral mucosa, lips and digits. They reported ten cases and extensively reviewed the literature up to that time. From the literature and by personal communication they were able to find twelve other proved cases. The syndrome was first reported by Peutz [*28*] in 1921, who described a family in which several members had pigment spots of the mouth, hands and feet associated with intestinal polyposis.

In reviewing the world literature in the seven years since that time we were able to find fifty-five additional case reports of this syndrome [*1–17,19–27, 29–45*]. We wish to report an additional case, thus raising the total number of reported cases to seventy-eight.

CASE REPORT

J. D., a twenty-one year old white man, was admitted to the San Francisco Veterans Administration Hospital on February 17, 1955, because of abdominal pain of three hours' duration. The pain was epigastric, constant, but with an intermittent, severe, colicky component occurring at irregular intervals every three to twenty minutes. He was nauseated but had not vomited. He had had a normal bowel movement six hours previously. No recent history of tarry stools was obtained.

The family history revealed the patient to have four siblings, all of whom had always been in good health. His parents also were living and well and on repeated questioning no history could be obtained of any family members with recurrent intestinal or abdominal problems. Knowledge was also denied of any relative with spots, freckles or pigmentations on the lips or in the mouth.

His past history revealed that at the age of fourteen years he had undergone laparotomy because of "telescoped bowel," the condition being corrected without intestinal resection. One year later a second laparotomy was performed for intestinal obstruction, apparently due to adhesions. A segment of small intestine was resected at this time. He remained well following this, although he did have approximately one episode monthly of recurrent upper and mid-abdominal cramping pain which was not severe and would subside spontaneously in a few minutes to an hour. This pain was unrelated to activity or the ingestion of food.

The patient was a twenty-one year old, well developed, white man, experiencing irregular episodes of severe abdominal pain. The rectal temperature was 98.6°F. His hair and eyes were brown and complexion slightly dark. The facial skin was freckled but with an unusual distribution of brownish spots on and around the lips, particularly on the lower lip, where there was some coalescence of the pigmented areas. There were also scattered similar spots on the buccal mucosa. (Fig. 1.) There was a mild pectus excavatum and the lungs were clear. The heart was normal by percussion and auscultation and the pulse rate 70 per minute and regular, while the blood pressure was 150/80 mm. Hg. The abdomen was soft. An oval shaped mass, 12 cm. in diameter, could be palpated in the epigastrium which was mobile, firm and somewhat tender; manipulation of this mass precipitated the patient's colicky pain. The bowel sounds were hypoactive. Well healed right and left rectus surgical scars were noted. No hernias were present. Rectal examination was not remarkable, and sigmoidoscopic examination to 18 cm. was normal.

The hemoglobin was 13 gm. and the white blood cell count 10,600 per cu. mm. The urinalysis and serologic tests for syphilis were normal. X-ray examination of the chest was normal. Roentgenograms of the abdomen with the patient in a supine and upright position were normal. Barium enema examination was normal except for a radiolucency in the terminal ileum. On February 23, 1955, there was another recurrence of the severe epigastric pain which subsided spontaneously. X-ray examination of the upper gastrointestinal tract on February 24, 1955, revealed an intussusception of the jejunum just distal to the ligament of Treitz, with a polyp, 4 cm. in diameter, as the leading point of

FIG. 1. Photograph showing distribution of pigmentation of lips.

FIG. 2. Roentgenogram of abdomen showing intussusception of jejunum and polyps in terminal ileum.

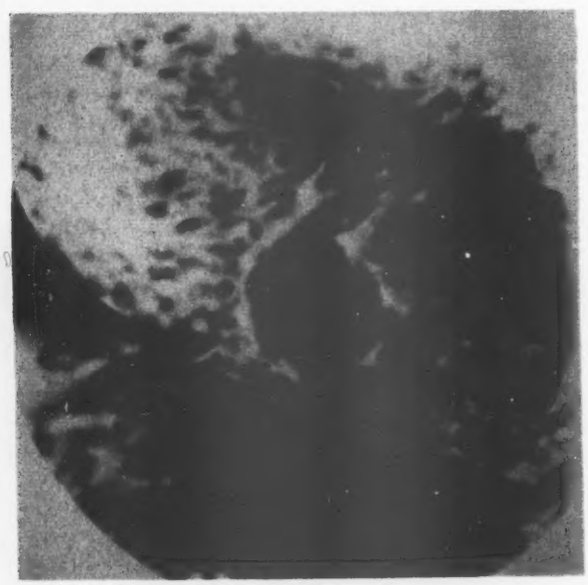

FIG. 3. Roentgenogram showing pedunculated small bowel polyp.

the intussusceptum. There was also redemonstration of the areas of suspected polyposis in the terminal ileum. (Fig. 2.) On March 2, 1955, laparotomy was performed. Just distal to the ligament of Treitz the jejunum was found to be intussuscepted for a distance of approximately 10 inches. The intussusception was easily reduced and found to be led by a sessile polyp 5 cm. in diameter. This was removed through an enterotomy. Additional pedunculated polyps, 1 cm. in diameter, were then found at approximately 1½, 4, 6 and 10 feet from the ligament of Treitz and these were excised through multiple enterotomies. A sixth polyp, 4 cm. in diameter and sessile, was removed from the terminal ileum through an enterotomy. Palpation of the stomach and colon revealed no other polyps.

The patient's postoperative course was uncomplicated, and he left the hospital on March 10, 1955.

The patient was subsequently seen several times at a surgical follow-up clinic and found to be completely asymptomatic.

X-ray series of the small bowel in September and October of 1955 and April of 1956 were normal. In October 1956, the patient was still asymptomatic. His hemoglobin was 15.6 gm. X-ray series of the small bowel, however, revealed at least two pedunculated polyps. (Fig. 3.) Because of the x-ray findings the patient was again admitted to the hospital on October 29, 1956. At this time he was still asymptomatic but since being seen in the clinic three weeks earlier he had noted some black stools.

Physical examination at this time revealed a healthy appearing young man. The temperature

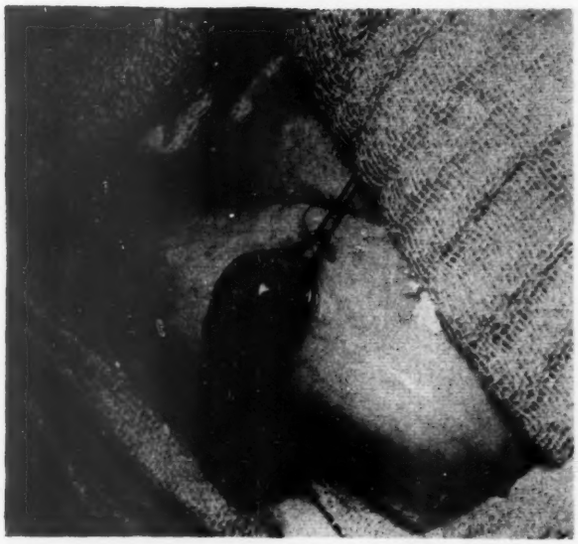

FIG. 4. Photograph of small bowel showing polyp extruding through enterotomy incision.

FIG. 5. Photomicrograph showing pedunculated small bowel adenomatous polyp. Original magnification, × 12.

was 98°F., pulse rate 80 per minute and blood pressure 140/80 mm. Hg. The peculiar pigmentation of the lips and oral mucosa was again noted. A few scattered pigmented spots were also noted on the fingers at this time. Examination of the chest and abdomen was unremarkable aside for the abdominal scars. Rectal examination revealed black stool.

His mother was questioned on this admission and stated that she noted the pigmentation on the patient's lips shortly after birth and initially even tried to wash it off, thinking it was dirt. She also noticed that the oral pigmentation, particularly of the upper lip, had decreased as he became older.

The admission hemoglobin was 14.2 gm., which was 1.4 gm. lower than that noted three weeks previously. The urinalysis was normal. Examination of the urine for the presence of melanin was negative. Bleeding, clotting and prothrombin times were within normal limits. Stool examinations on three occasions were strongly positive for occult blood.

Sigmoidoscopy revealed a small mammillary polyp, ¼ cm. in diameter, at 8.5 cm. but was otherwise normal to 20 cm.

Roentgenogram of the chest was normal. A barium enema examination revealed no large bowel polyps. A repeat x-ray examination of the small bowel showed three definite pedunculated polyps, two in the jejunum and one in the ileum.

Laparotomy was performed on November 7, 1956, through a right rectus incision. Palpation of the colon, stomach and duodenum revealed no detectable polyps. The small intestine was then systematically examined, beginning at the ligament of Treitz, and two jejunal polyps were discovered at approximately 4 and 8 inches from the ligament of Treitz, and a third polyp discovered in the mid-portion of the ileum. The polyps were pedunculated and ranged in size from ½ to 1 cm. in diameter. The second jejunal polyp was the largest and its mucosa noted to be very friable. The polyps were excised through multiple enterotomy incisions. (Fig. 4.)

Pathological examination of the polyps removed on both admissions revealed them to be benign, adenomatous polyps. (Fig. 5.)

The patient's postoperative course was uneventful and he was discharged from the hospital on November 14, 1956.

COMMENTS

According to Jeghers the syndrome consists of two features: distinctive melanin spots of the buccal mucosa and lips and polyposis of the small intestine. This case fulfills those criteria. Also, he displayed the additional features of pigmentation of the digits and the presence of a large bowel polyp. Associated pigmentation of the digits and the presence of additional large bowel or gastric polyps may, and frequently do, occur, together with the above two features but are not essential characteristics of the syndrome.

In addition, Jeghers believes the syndrome to be of an hereditary nature, probably being inherited as a simple Mendelian dominant. In this case we were unable to demonstrate the hereditary feature. However, sporadic cases do occur. In many of the reviewed case reports no family history was obtainable. Also, as Jeghers points out, frequently close family members are unaware of the oral pigmentation.

It is not our purpose to discuss the various features of this syndrome since this has already been done most completely by Jeghers et al. We do believe, however, this case to be interesting in that it exemplifies a "typical" case of Jeghers' syndrome, not only as pointed out by Jeghers, but also as representing the usual type of the fifty-five cases reported since then.

First, the pigmentation of the patient's lips and oral mucosa is characteristic and has been present since infancy, if not birth. The dermal portion of the pigmentation, however, has tended to fade. His complexion is dark with brown hair and eyes. The patient is young and his symptoms date back to early adolescence. Abdominal pain and finally intestinal obstruction due to intussusception of the small intestine was the symptomatic part of the syndrome. Bleeding was also present. It also has been necessary to subject him to multiple laparotomies. The polyps were most frequent in the jejunum. They were mostly pedunculated and were all of the benign, adenomatous type. Finally, adequate management appears to consist of surgical removal of the polyps in combination with close medical follow-up.

CONCLUSION

A typical case of Jeghers' syndrome has been presented.

There is considerable controversy as to whether or not patients with this syndrome should undergo repeated laparotomies for removal of asymptomatic polyps as soon as they are demonstrated radiologically. A clear-cut answer to this problem is not apparent at this time.

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Fatal Perforation of the Thoracic Aorta by a Gastric Ulcer

A LATE COMPLICATION OF ESOPHAGEAL RESECTION

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A REVIEW of the recorded experiences with esophagogastrostomy reveals that although peptic ulceration of the esophagus or stomach is a known sequel, perforation of the aortic wall by the ulcer has not been recorded. Because of its rarity, such a complication is reported.

CASE REPORT

The patient, a twenty year old Negro man, was first admitted to Grady Memorial Hospital in September 1949, immediately following the ingestion of a lye solution. Approximately a half hour prior to admission, in a suicidal attempt, he had attempted to drink a solution of lye (one teaspoonful of potassium hydroxide in a glass of water), but the glass had been knocked from his hands before much of the fluid was swallowed. Vomiting had occurred immediately thereafter; the vomitus contained blood and partially digested food.

Following his admission to the emergency clinic, gastric lavage with a dilute acetic acid solution was instituted. Examination of the oropharynx revealed burns of the tongue and of the mucous membranes of the soft palate and pharynx. Rhonchi were present throughout both lung fields. The abdomen was soft, but mildly tender in the epigastrium.

Parenteral fluids and antibiotic therapy were instituted shortly after admission, oral fluids and food being withheld. During the first six days in the hospital his course was febrile (101° to 104°F), and epigastric and substernal pain persisted. Barium studies revealed an irregularity in the esophageal mucosa, but no fistula was detected.

Because of his difficulty in swallowing fluids, a gastrostomy was performed on the twenty-first day of hospitalization. He tolerated gastrostomy feedings well. Following continued improvement, esophagoscopy was done on the thirty-ninth hospital day. A stricture, 37 cm. from the incisor teeth, was encountered. Dilatation with bougies was instituted and was continued until a No. 30 bougie could be passed without difficulty.

The patient then refused further therapy and was not seen again until he returned two months later with complete obstruction of the esophagus at the level of the fifth thoracic vertebra. Retrograde dilatations were begun, but again the patient refused further treatment.

Two months later, he again returned with complete esophageal obstruction. Surgical excision of the involved esophagus was elected. Exploration through the right side of the chest permitted resection of the esophagus from the arch of the aorta to the cardia. Marked scarring was present throughout the resected esophagus and throughout the other mediastinal structures. The stomach was brought anterior to the aortic arch in order to permit esophagogastrostomy.

Postoperatively his course was complicated by atelectasis and infection requiring intercostal drainage, bronchoscopy and antibiotics.

The patient was then followed in outpatient clinics for the next year until February 1951, when he experienced pain in the right lower thorax, regurgitation of food particles and an episode suggestive of hemoptysis. Roentgenographic studies failed to reveal the anticipated bronchoesophageal fistula, but showed instead, a large ulcer in the antrum of the stomach and stenosis of the esophagogastric stoma. (Fig. 1.) His anemia (hemoglobin 6.2 gm. per cent) was corrected by transfusion and he was placed on a regimen of frequent feedings and parasympatholytic drugs. He again left the hospital against advice. Six months later, the ulcer crater was again demonstrated in the stomach. Again transfusions were necessary to correct his anemia (hemoglobin 5.2 gm. per cent).

Readmission was necessary after ten months because of severe anemia, (hemoglobin 3.8 gm. per cent). Barium studies demonstrated a marked con-

FIG. 1. X-ray film of chest in February, 1951 showing dilatation of the esophagus proximal to the stenosed esophagogastric anastomosis.

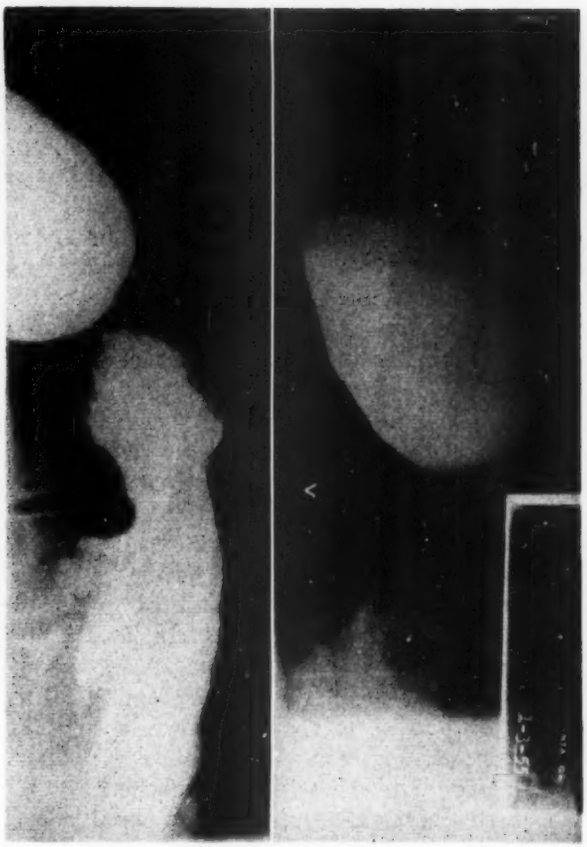

FIG. 2. Spot films taken in January, 1955 showing increase in proximal esophageal dilatation, stenosis of the anastomosis and a large gastric ulcer.

striction of the esophagogastric stoma. Again the response to conservative therapy was gratifying.

In March 1954, four years following resection, a gastrointestinal series revealed enlargement of the ulcer, the ulcer being located on the posterior wall of the stomach, 4 cm. below the anastomosis. Continued observation revealed recurrent episodes of esophageal obstruction requiring repeated dilatations with soft bougies. (Fig. 2.) He refused surgical reconstruction of the esophagogastrostomy.

In February 1957, seven years postresection, he was seen as an outpatient, complaining of severe pain in the right side of his chest and in the right flank. Examination revealed no abnormalities. Two days later he was brought to the emergency clinic, following the sudden onset of massive hematemesis. The intervening history was that of severe, sudden pain in the right side of the chest with radiation to the back. He was in profound shock, his blood pressure responding to whole blood transfusions by a rise to 90/60 mm. Hg. Massive hematemesis continued, the blood being bright red. Immediate exploration was elected. Following induction of anesthesia, his blood pressure again became imperceptible but operative hemostasis was deemed essential. Exploration through the right side of the chest revealed the large ulcer to be overlying and perforating the anterior wall of the thoracic aorta. Tamponade permitted isolation and occlusion of the involved aortic segment. The resected segment, 5 cm. in length, was replaced with a nylon knit graft. The blood pressure remained imperceptible. Cardiac arrest occurred, but resumption of a forceful cardiac contraction and a normal sinus rhythm developed after forty-five minutes of massage.

The patient reacted, talked coherently and was able to move all extremities. He was anuric, however, and developed increasing respiratory distress which was not relieved by tracheotomy. He died three hours postoperatively.

Autopsy revealed the residual benign ulcer on the posterior surface of the stomach. The ulcer measured 6 cm. in diameter and overlaid the aorta. A 2 to 3 mm. perforation was present anteriorly in the resected portion of the aorta.

COMMENTS

Although fistulas between the stomach and the thoracic aorta have not been previously reported, aortoesophageal and anastomotic fistulae have been noted.

Aortoesophageal fistulas can be divided into two groups depending on whether the primary

or initiating lesion is in the thoracic aorta or in the esophagus.

Aortoesophageal fistulas due to erosion of the esophagus by a primary disease of the thoracic aorta is not too rare, rupture of thoracic aortic aneurysms into the esophagus being a well recognized entity. In Kampmeier's [5] report of 633 patients with saccular aneurysms, rupture occurred in ninety-eight instances. In twenty (20.4 per cent) of these patients the rupture was into the esophagus. Boyd [2], in a survey of 4,000 collected patients with thoracic aneurysms, found that of those aneurysms which ruptured, the perforation was into the esophagus in 9.4 per cent. More recently, aortic rupture into the esophagus has been reported by Calenda [3] and by Krudy [6].

The fistulas which form as a result of primary esophageal lesions are probably more common than the group just described. It is into a category similar to this that our patient falls. Perforation of a carcinomatous ulcer of the esophagus into the aorta occurs infrequently. Carr [4], in 1922, found only twenty-two such complications described in the literature; Schattenberg [10], added another.

Benign esophageal ulcers occasionally are responsible for perforation of the aorta. Most of the fistula of esophageal origin are traumatic in origin, resulting from ingested foreign materials. A safety pin, wire, coins, fish bones, and numerous other objects have been described as precipitating the trauma [1,12]. These ingested objects have characteristically produced perforation followed by a periesophagitis and abscess leading subsequently to erosion and rupture of the aorta.

Maguire [7] reported a perforation of the thoracic aorta which occurred forty days following resection of an esophageal carcinoma and esophagogastrostomy. Leakage had occurred through a defect in the anastomosis, resulting in a periesophagitis which eventually eroded the thoracic aorta. Merendino [8] reported two similar complications. In one patient, the aorta was traumatized by a misplaced suture which was passed through the media of the aorta during the esophagogastric anastomosis. In the other, an abscess formed at the esophagogastric suture line with subsequent erosion of the aorta and the establishment of a fistula. Neither of the patients was reexplored. Our experience is unique in that perforation of the aorta occurred seven years after esophagogastrostomy for an extensive lye stricture of the esophagus. The gastric ulcer, recognizable by roentgenographic examination for six years prior to acute aortic perforation, was situated below a stenotic esophagogastric anastomosis. Forty-eight hours prior to the acute episode, the patient complained of a severe boring pain. This pain, in retrospect, suggests a deeper penetration of the gastric ulcer and was the unrecognized forerunner of the fatal aortic perforation.

One of Merendino's patients lived ninety-five minutes after the first episode of syncope, pain and hematemesis; the other lived sixteen hours; our patient lived six hours.

This complication of esophagogastrostomy should be recognized in order to permit prophylactic or emergency exploration. Resection of the involved aorta with restoration of aortic continuity would seem the treatment of choice once the perforation has occurred.

SUMMARY

Perforation of the aortic wall by a gastric ulcer occurred seven years after esophagogastrostomy for an extensive lye stricture of the esophagus. Such a complication has not previously been reported.

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BOOK REVIEWS

The Management of Abdominal Operations. Edited by Rodney Maingot, F.R.C.S. Second edition in two volumes, 1,326 pages, with references at chapter endings; name and subject indexes. 640 illustrations in 444 figures. With thirty-two contributors. New York, 1957. The Macmillan Company.

Topographically the two volumes are beautifully done; they are handsome, and well printed and illustrated. The chapters by the contributors also are above average. (In so many instances this is not so.) In Maingot's two volumes the work of the contributors has reached a high scientific surgical level.

The first edition had a wide appeal. In this edition the format has been changed. The two handy volumes each contain a comprehensive index, many of the former illustrations have been replaced by new ones, and over 200 original half-tone pictures of operative procedures have been included. One-third of the work is devoted to considerations which are essentially physiological. All in all this is a most satisfactory surgical work from all viewpoints, which will make an ideal gift to the intern, resident or young man beginning the practice of surgery.

Gynecologic Surgery and Urology. By Thomas L. Ball. M.D., Assistant Professor of Obstetrics and Gynecology, Cornell University Medical College; Associate Attending Obstetrician and Gynecologist, The New York Hospital, New York, N. Y. Foreword by R. Gordon Douglas, M.D., Professor of Obstetrics and Gynecology, Cornell University Medical College; Obstetrician and Gynecologist-in-Chief, The New York Hospital, New York, N. Y. 547 pages, with 161 full page plates by Daisy Stilwell; references at chapter endings and an index. St. Louis, 1957. C. V. Mosby Company. *Price* $20.00.

A compendium of standard accepted procedures in this field as they have been evaluated, modified and developed by Dr. Ball and his colleagues at the Cornell Medical Center. This work will prove of value in teaching the regional approach to gynecology and gynecologic surgery both to the resident surgeon and to the practicing specialist who desires to keep abreast of the most acceptable modern development in this field.

The author writes well and has eliminated all unnecessary verbiage. The illustrations are far above the average. Unreservedly recommended.

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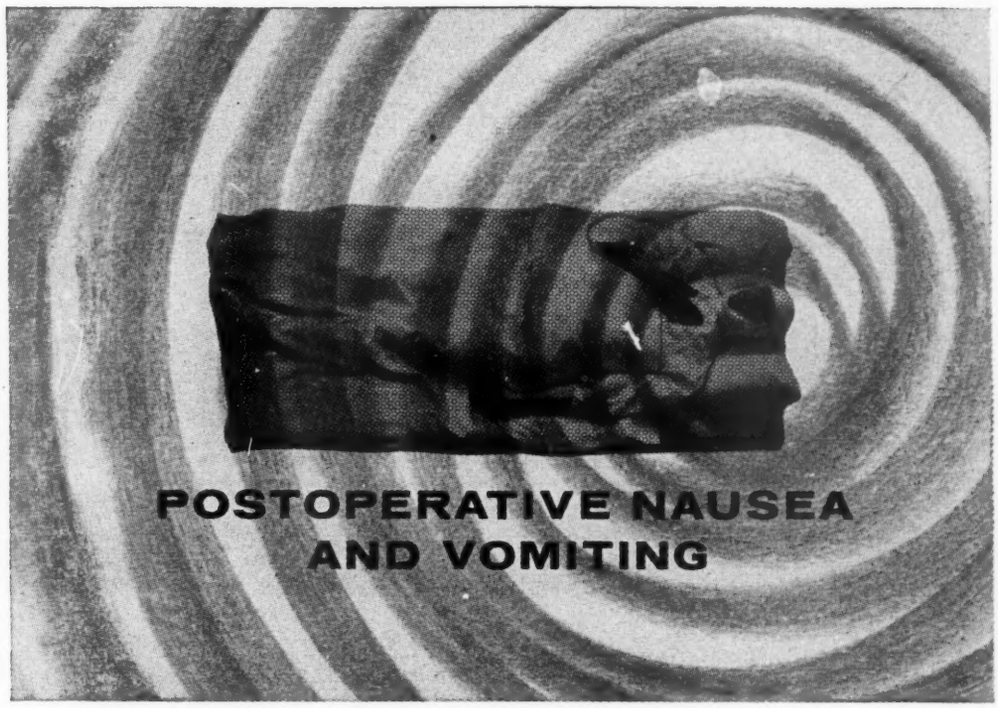

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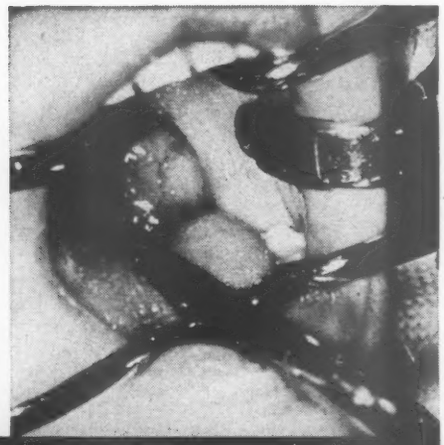

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1. Ryan, E. R.: A New Aid to Tonsil and Adenoid Surgery, *Clinical Medicine*, 5, 327 to 331, (March) 1958.

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1. Pulaski, E. J., and Isokane, R. K.: Surg., Gynec. & Obst., 104:310, March 1957.
2. Petersdorf, R. G., Curtin, J. A., and Bennett, I. L.: Arch. Int. Med. 100:927, December 1957.

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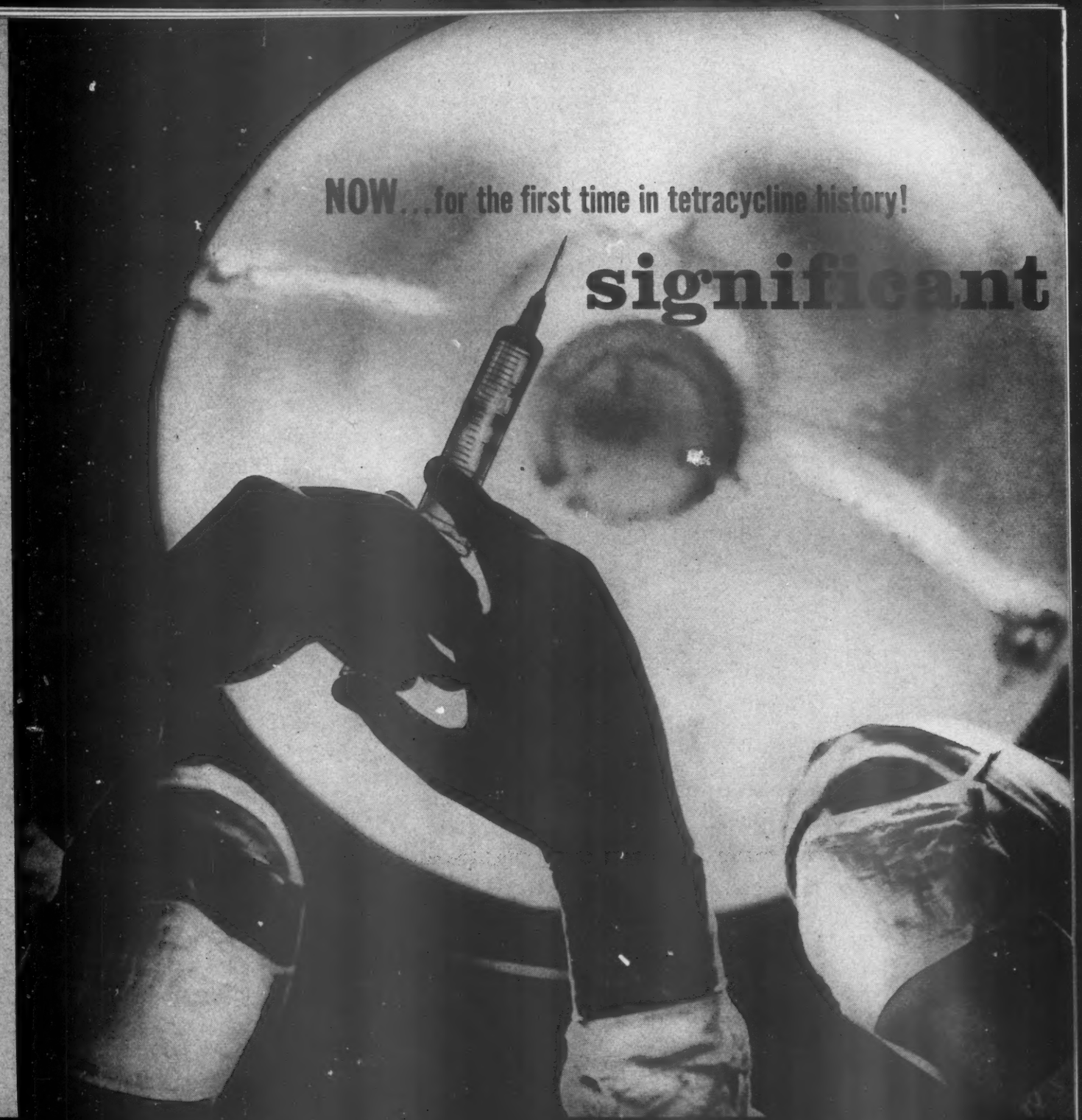

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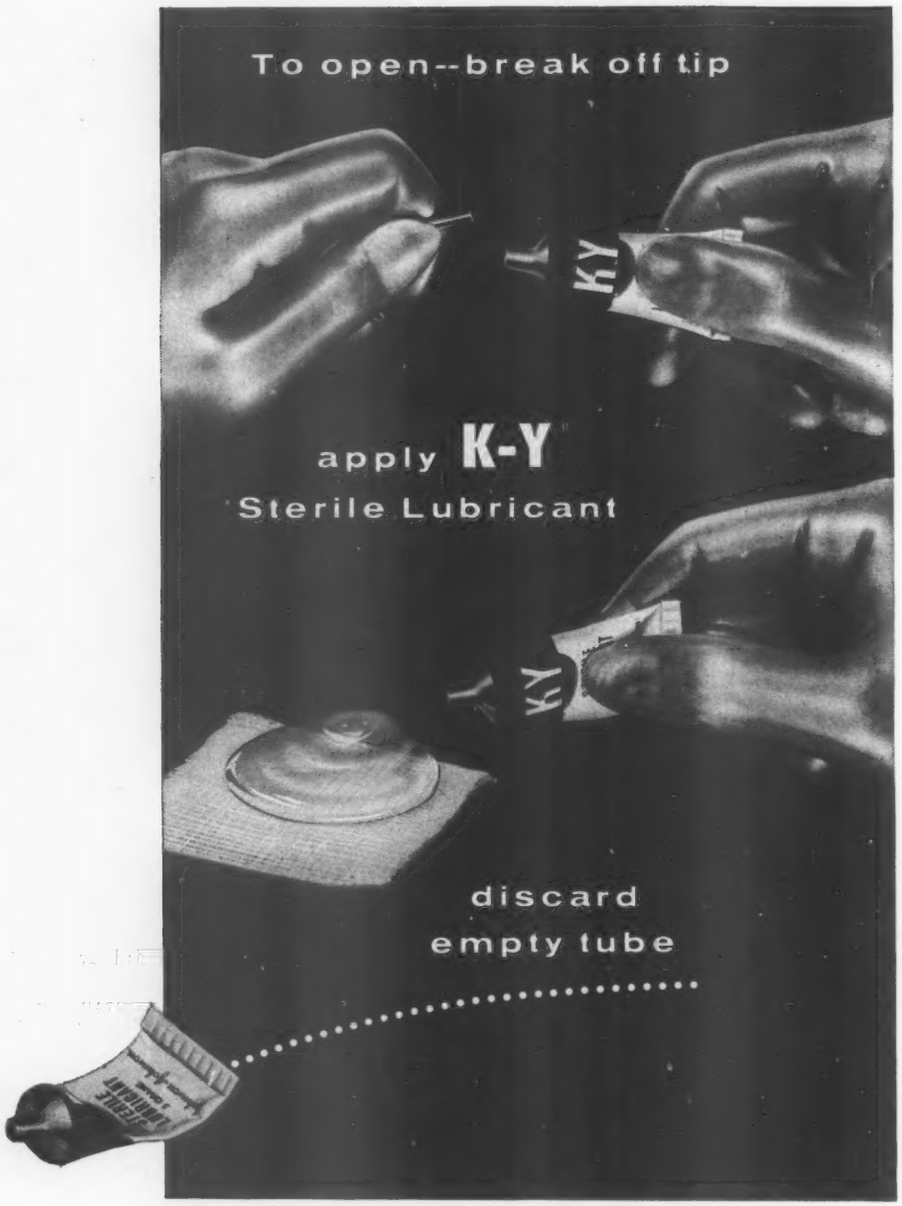

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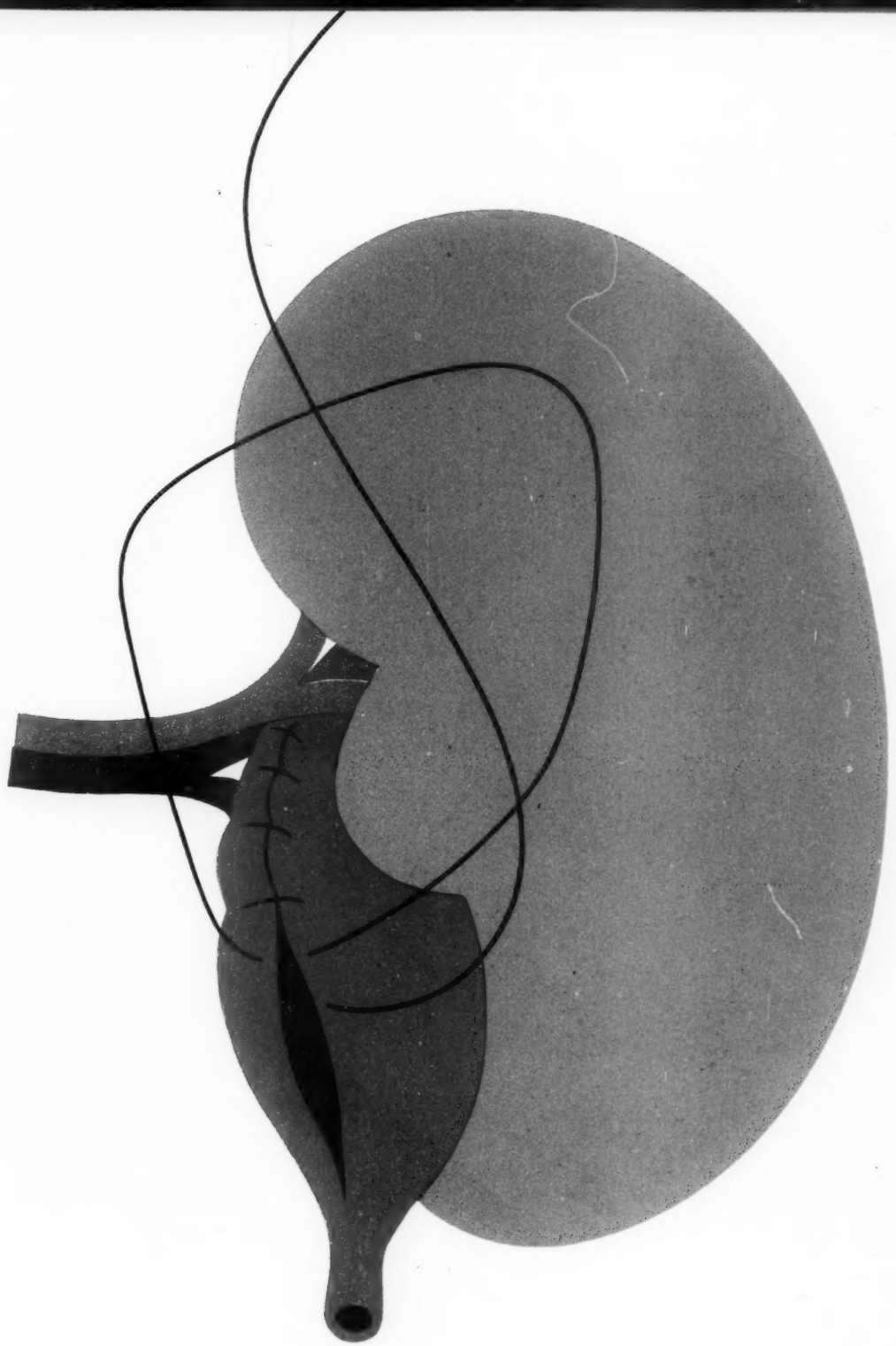

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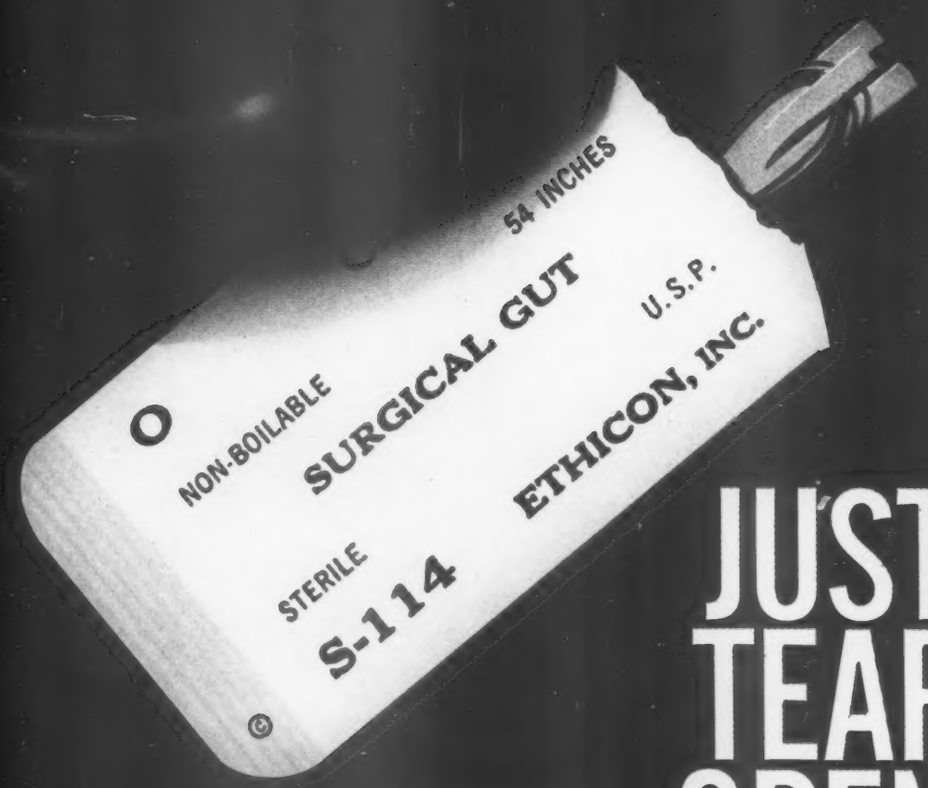

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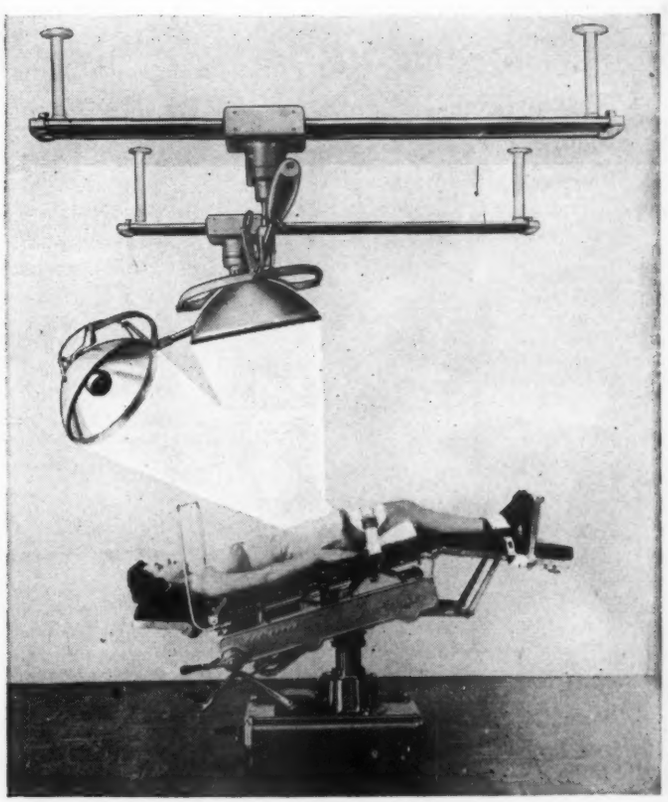

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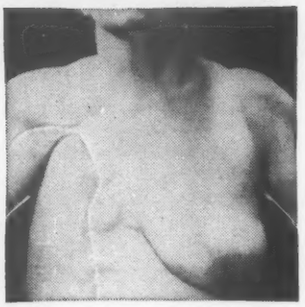

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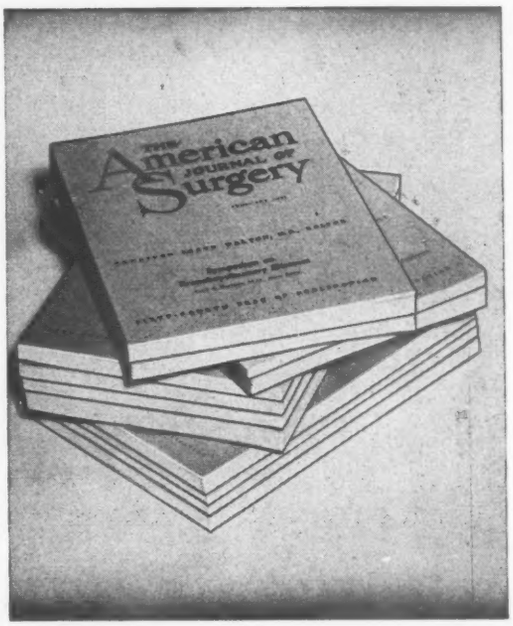

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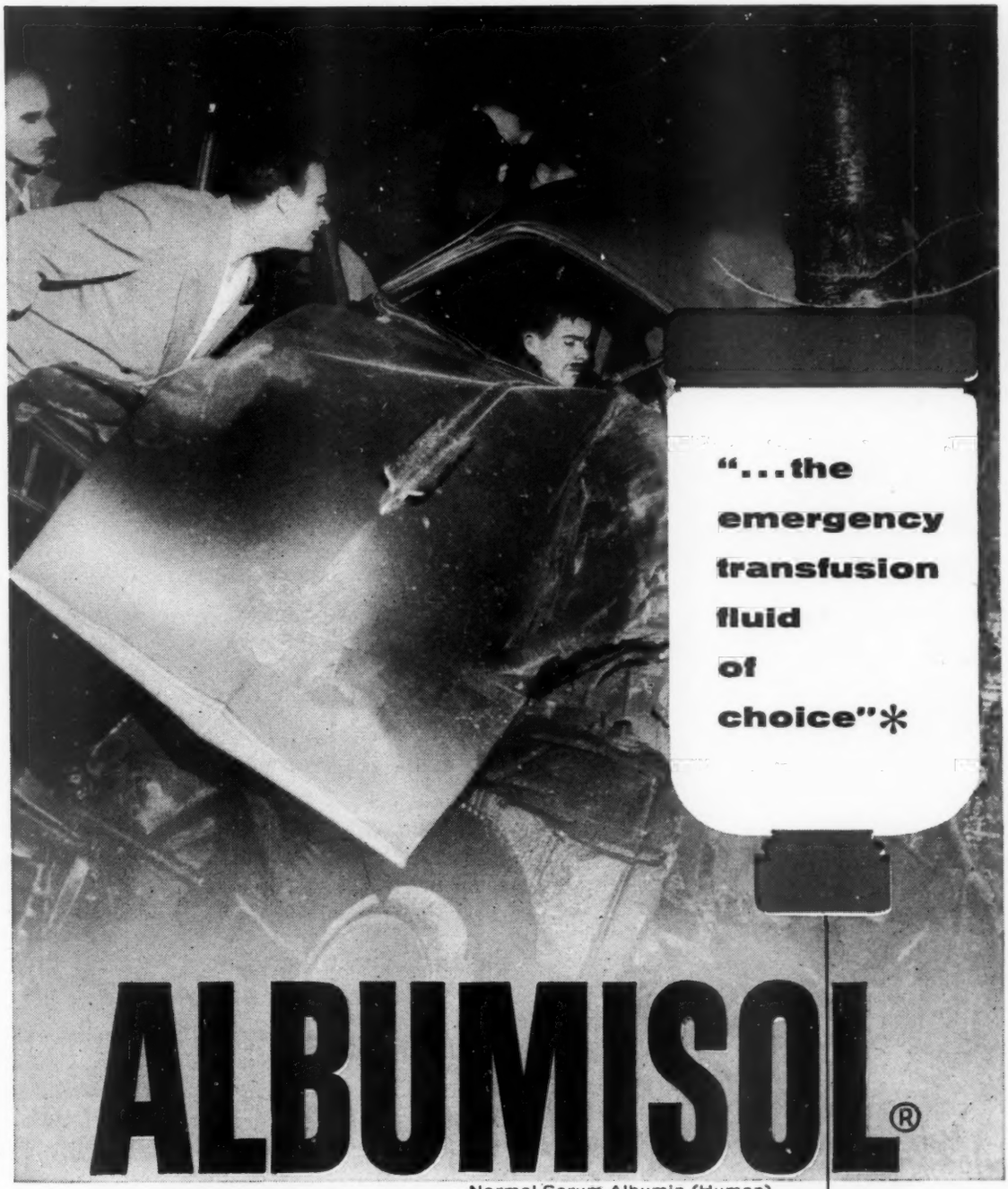

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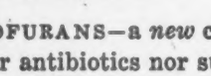

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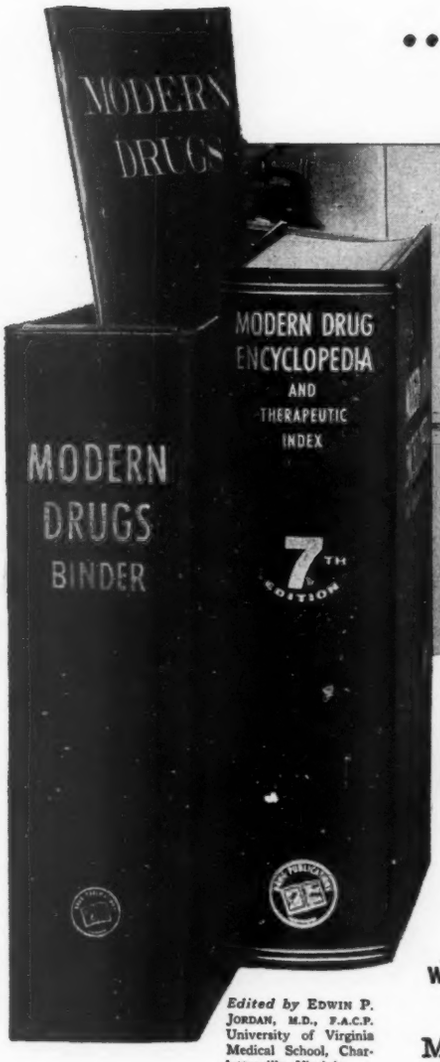

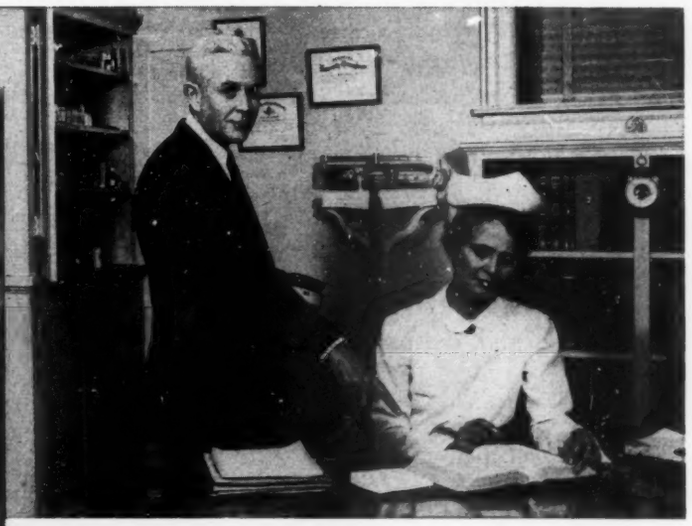

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NOTES AND QUOTES

AMERICAN GOITER ASSOCIATION. The 1958 meeting of the American Goiter Association will be held in the St. Francis Hotel, San Francisco, California, June 17, 18 and 19, 1958. Hotel reservations must be secured by writing to Goiter Housing Bureau, Room 300, 61 Grove Street, San Francisco, California, and including a deposit of $10.00 per room.

The program for the three-day meeting will consist of papers and discussions dealing with the physiology and diseases of the thyroid gland.

HAVING A BABY. *Having a baby is not only safer for both mother and child now than it was twenty-five years ago but also, measured in equal dollars, it is about 18 per cent less expensive, the Health Information Foundation disclosed recently.*

In a detailed report on maternity costs for medical care in its monthly statistical bulletin, Progress in Health Services, *the Foundation reported that in the 1928–1931 period, the average total cost for a hospitalized obstetric patient was $160 or, in terms of present day dollars, $258. Today the average total cost is $213, an average decrease of $45 per case, or 18 per cent.*

Hospital costs for maternity care have dropped about 10 per cent since 1930, or more than 25 per cent when the cost of special nursing service is included (such service is almost never necessary today). Twenty-five years ago the average hospital charge for a maternity patient was $64, or $102 when inflationary factors are added. Today's average is $92.

Physicians' fees for obstetrical care have increased slightly, by about 9 per cent, since 1930. But this is a small increase, says the Foundation, because the average mother-to-be now gets more prenatal care than ever before, and an increasing amount of obstetric service is being provided by specialists with added years of professional training.

PREGNANCY HORMONE. New reports on the use of the hormone, relaxin, to ease delivery and reduce complications of childbirth were presented recently at a "Conference on the Uterus" sponsored by the New York Academy of Sciences.

Dr. Charles Birnberg of the Brooklyn Jewish Hospital described his work with Cervilaxin, a form of relaxin, and declared it to be a valuable adjunct to the obstetrician's armamentarium. Properly used in conjunction with another hormone called oxytocin the most painful stage of labor can be shortened to an average of thirty minutes for mothers who have already had a previous child. For mothers having their first child the average delivery time is about sixty minutes. According to Dr. Birnberg, these time intervals represent a significant reduction (50 to 60 per cent) over those found in patients treated with oxytocin alone.

Similar success was obtained using Cervilaxin and oxytocin for the rapid induction of labor. Thus, "babies by appointment" are possible within one hour from the time of drug administration.

The certainty of results following the proper use of Cervilaxin and oxytocin is of great help in determining whether delivery can be accomplished without having to resort to surgical technic. If delivery is not accomplished within the prescribed times, it is quite certain that normal vaginal delivery cannot take place and surgical methods will be required. This therapeutic test dispenses with the usual long period of unproductive labor and reduces the incidence of fetal injury as well as maternal trauma, exhaustion and infection.

NEW DRUG FOR TUBERCULOSIS. *A new synthetic drug, thiocarbanidin, will be tested against tuberculosis by the Veterans Administration, it was recently announced.*

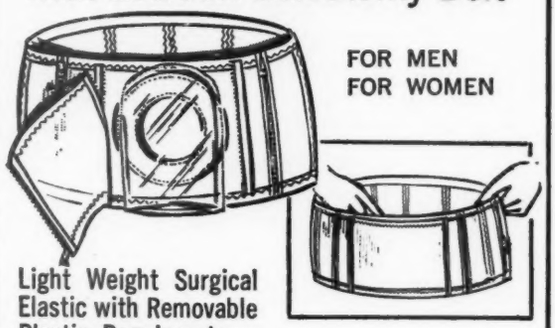
The study will be part of the V.A.'s continuing project for the clinical trial of newer tuberculosis drugs in cooperation with the Armed Forces, which has produced findings leading to present use of tuberculosis therapies by the entire medical profession.

The V.A. said use of thiocarbanidin in humans and in animals, reported by guest speakers at the V.A.'s recent annual tuberculosis meeting, indicates the drug has no ill effects and may be helpful to patients for whom treatment with other tuberculosis drugs is not satisfactory.

V.A. doctors hope the new compound may prove to be an acceptable substitute for PAS, one of the widely used tuberculosis drugs.

CONTINUED ON PAGE 52

New Comfort and Security with Lou-Jen Colostomy Belt



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PAS causes nausea and vomiting in some patients, and some have developed resistance to this drug so that it is no longer useful against their infections.

Thiocarbanidin is given by mouth in small doses, and its therapeutic effect is reported to be similar to that of PAS, the V.A. said.

The new drug will be given to V.A. patients in combination with streptomycin or isoniazid. The agency is developing plans as to which hospitals will use thiocarbanidin, how long the study will be, and the number and type of patients to be selected.

ATOMIC "PHOTOGRAPHS." Atomic "photographs" are enabling Veterans Administration doctors to diagnose internal cancer that cannot be found by other methods.

Dr. W. Edward Chamberlain, Chief of the V. A. atomic medicine program in Washington, D. C., said the technic first was applied at the V. A. center in Los Angeles and now is proving increasingly helpful in the care of patients at V. A. hospitals across the nation. He said the pictures are called scintigrams, which are used somewhat as x-ray films.

Scintigrams are made with a device known as a scanner that records radiation from doses of radioisotopes. Impulses from radioisotopes within the patient's body form dots on paper inserted into the scanner. The dot pictures indicate clearly the areas of concentration of radioisotopes, so the doctors may estimate the size of internal organs and diagnose the presence of cancer.

NEW ARMY ARTIFICIAL RESPIRATION METHODS. *The Old Testament account of how Elisha revived the dead son of the Shunammite (II Kings 4: 34) and the recent work of medical scientists of the Army Medical Service may prove that when it comes to artificial respiration there is nothing new under the sun. Working under contracts with the Research and Development Division of the Army Medical Service, Drs. James O. Elam and David G. Greene of Buffalo, New York, and Peter Safar of Baltimore, Maryland, have shown that the mouth-to-mouth or "Biblical" method of artificial respiration is superior to any yet devised.*

Using modern scientific methods and equipment to make precise measurements, Drs. Elam, Greene, and Safar found that the mouth-to-mouth method enables the operator to deliver far more air to the patient's lungs than does the "prone pressure," "prone pressure-arm lift," or any other more conventional method of artificial respiration. By hyperventilating slightly, the mouth-to-mouth operator can keep the oxygen and carbon dioxide content of a non-breathing patient's blood nearly normal for prolonged periods.

The development of the mouth-to-mouth method, which is being adopted as the preferred method by the American National Red Cross, the Baltimore City Fire Department, the New York State Heart Assembly, and various medical societies, resulted from the efforts of the Army to devise methods for rendering adequate first aid to paralyzed "nerve gas" casualties.

ANNOUNCEMENT. The 1958 Bar-Ray catalog on x-ray accessories, isotope and inspection equipment, radiation protection and film processing equipment is now available. It contains fifty-six pages of photographs, illustrations, diagrammatic drawings, specifications and product information. It also describes the latest developments in processing tanks, showing twenty full-color pamelon exterior finishes. For free copy address Bar-Ray Products, Inc., 209 25th St., Brooklyn 32, N. Y.

POLIOMYELITIS. *A special effort to have children under five vaccinated against polio was announced today in the wake of new evidence that this is the age group with the highest attack rate for paralytic polio.*

Surgeon-General Leroy E. Burney of the Public Health Service said he had called this information to the attention of the American Academy of Pediatrics and the American Academy of General Practice, and that both will encourage vaccination of children under five.

The Public Health Service will continue to urge vaccination of all persons under forty, with special emphasis on the under five age group, and the Children's Bureau, also an agency of the Department of Health, Education, and Welfare, will join in this phase of the campaign, Dr. Burney said.

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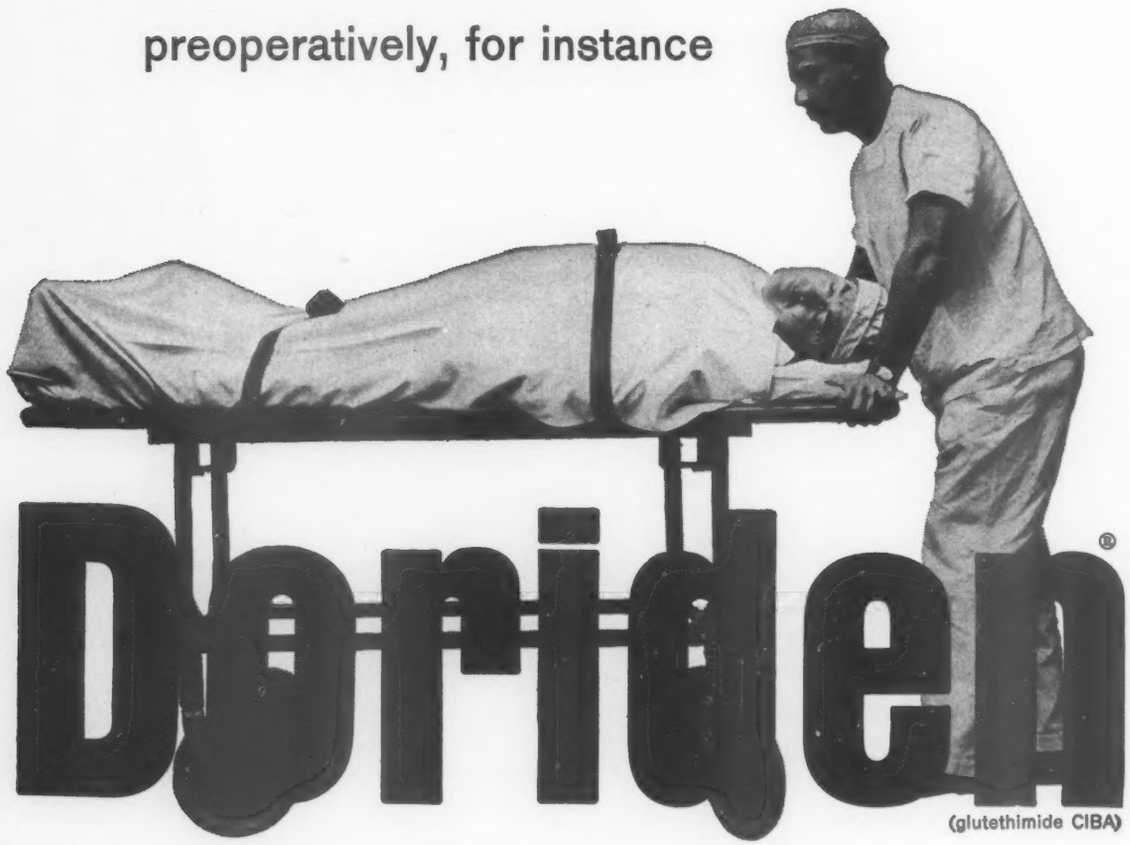
Less restricted* sedation . . .

preoperatively, for instance



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*SEDATION WITH DORIDEN IS LESS RESTRICTED because, unlike barbiturates, it is not contraindicated where renal and hepatic disorders are present; unlike many barbiturates, Doriden rarely causes pre-excitation; unlike barbiturates traditionally used for sedation, Doriden is metabolized quickly, thus rarely produces "hangover" and "fog."

SUPPLIED: TABLETS, 0.125 Gm., 0.25 Gm. and 0.5 Gm.

1. Matlin, E.: M. Times 84:68 (Jan.) 1956.

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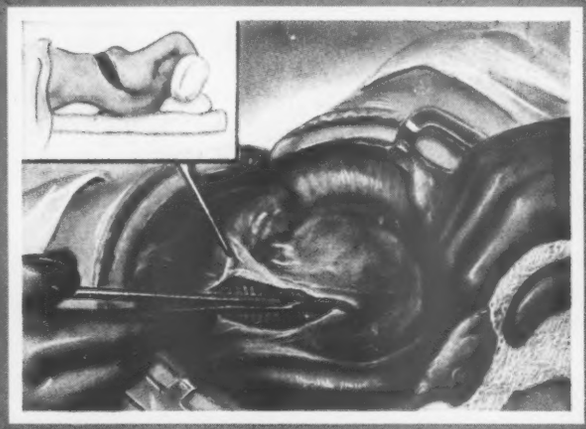
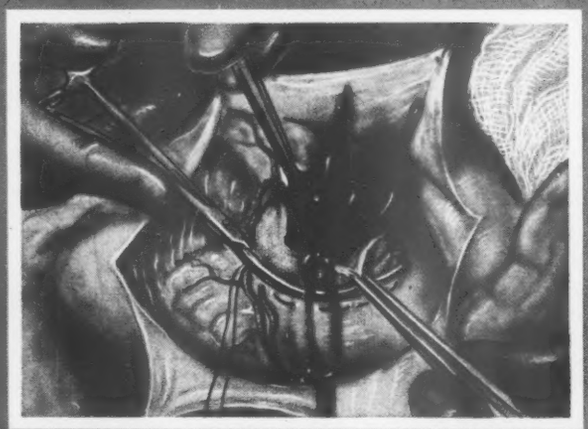
KEY ADVANCES IN OPERATIVE TECHNICS*—*Mitral Commissurotomy*[1]

1. Anterior postero-lateral view of heart. Note greatly dilated left auricle and calcified, thickened mitral valve. Inset shows typical narrowing of valve viewed from above.



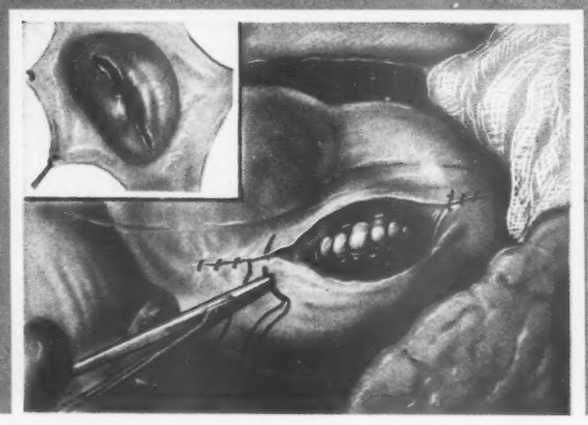
2. Postero-lateral periscapular incision. Enlargement of left ventricle and pulmonary artery is evident. Dilated left auricle presses on esophagus. Pericardium is being incised just posterior to the phrenic nerve.

3. A purse string suture is placed around the auricular appendage. This suture is carefully started just above the circumflex artery.



4. A clamp placed just above the suture line is released slightly allowing a gush of blood to wash away any accumulated thrombotic material. Purse string suture is then tightened.

5. Finger is inserted into auricle. Inset (left) shows finger about to dilate valve. Inset (right) depicts alternate procedure with guillotine knife fastened to finger for rigid valve.



6. The auricular appendage is closed by means of the purse string and a whipstitch suture. The pericardium is left partially open. Inset shows an adequate commissurotomy.

Mitral commissurotomy is one of a series of surgical drawings in color illustrating important new operations successfully perfected during the past decade. It is brought to you as a service by Seamless, the world's largest manufacturer of surgeons' gloves. If you would care to examine any of the Seamless Gloves . . . Brown Milled, White or Brown 'Limber-Latex', or the new 'Crest' for eye, brain or heart surgery, write for a sample giving your glove size.

**Based on an opinion survey of 2,500 general surgeons.*

1. Glover, R.P., *International Symposium on Cardiovascular Surgery*, Edited by Conrad R. Lam, (Philadelphia: W. B. Saunders Company, 1955), pp. 179-211.

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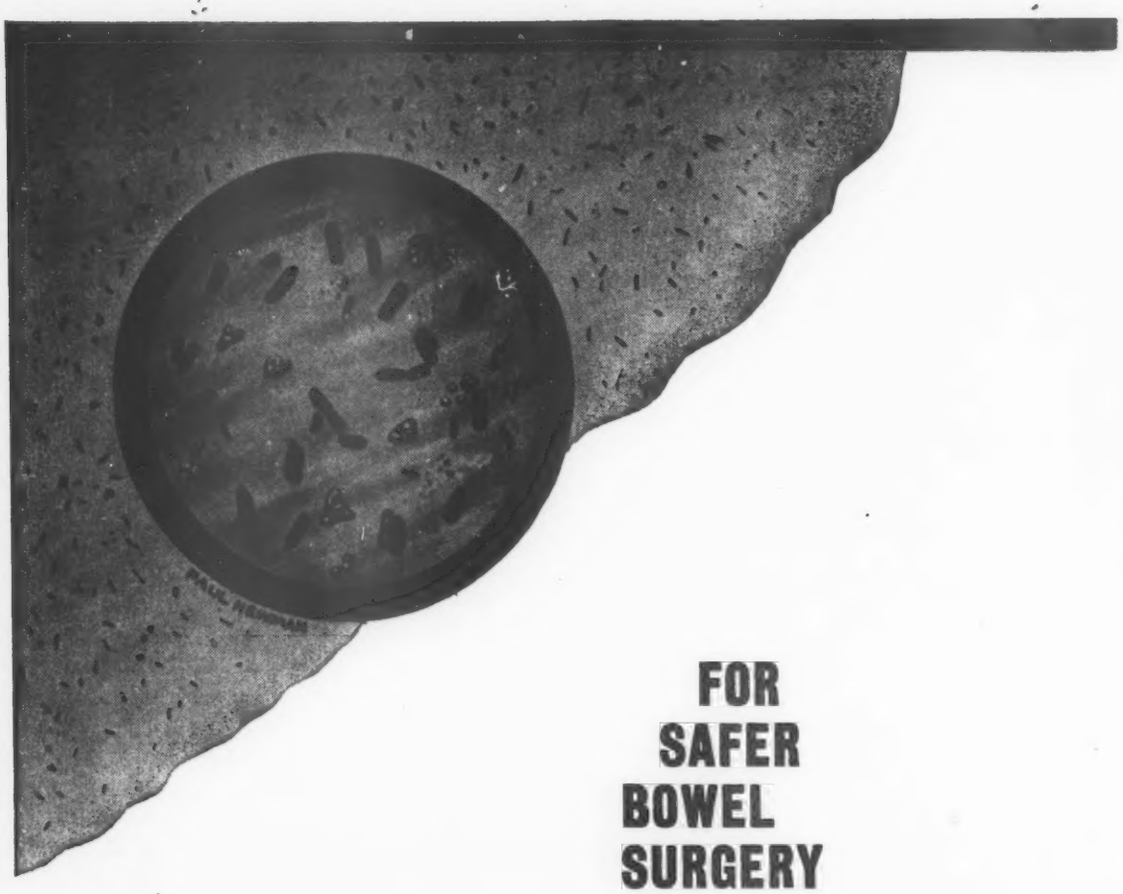

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